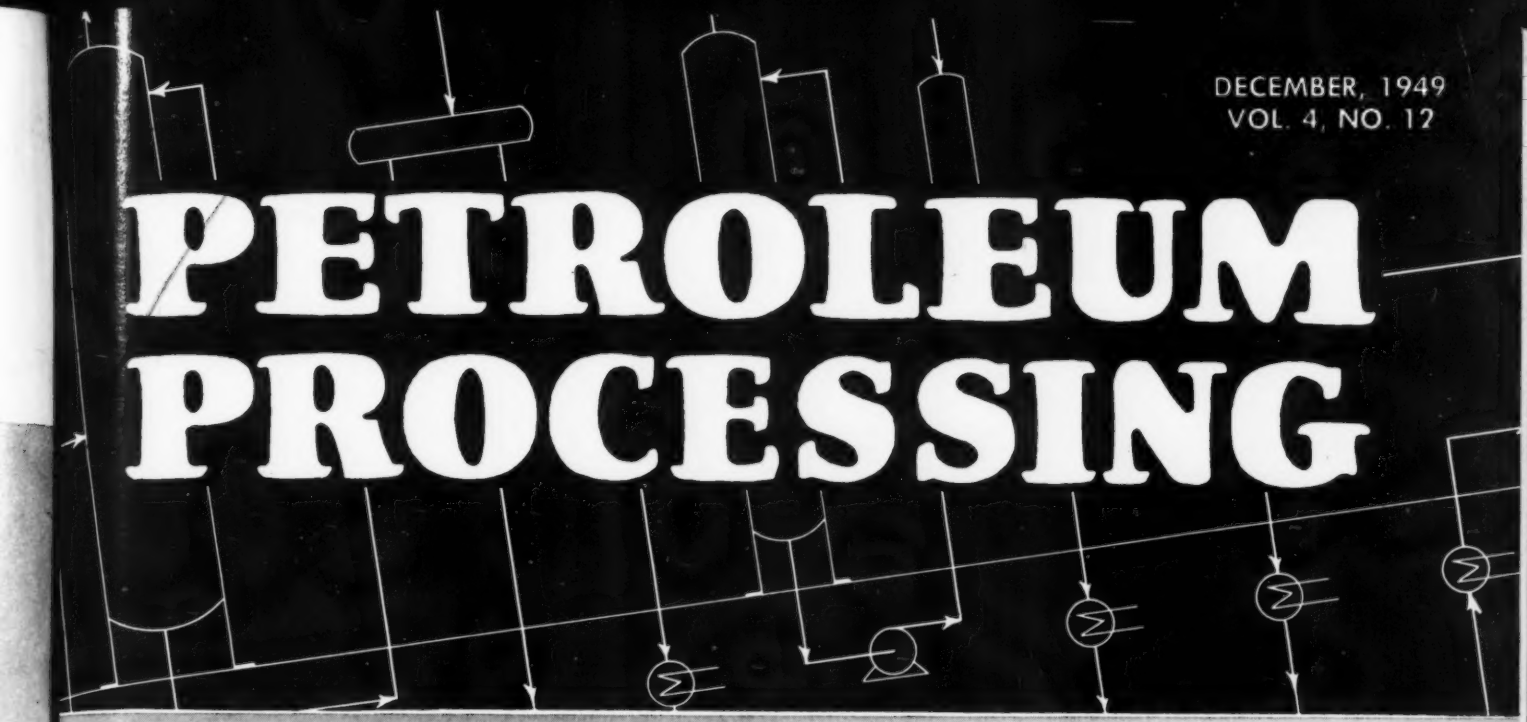
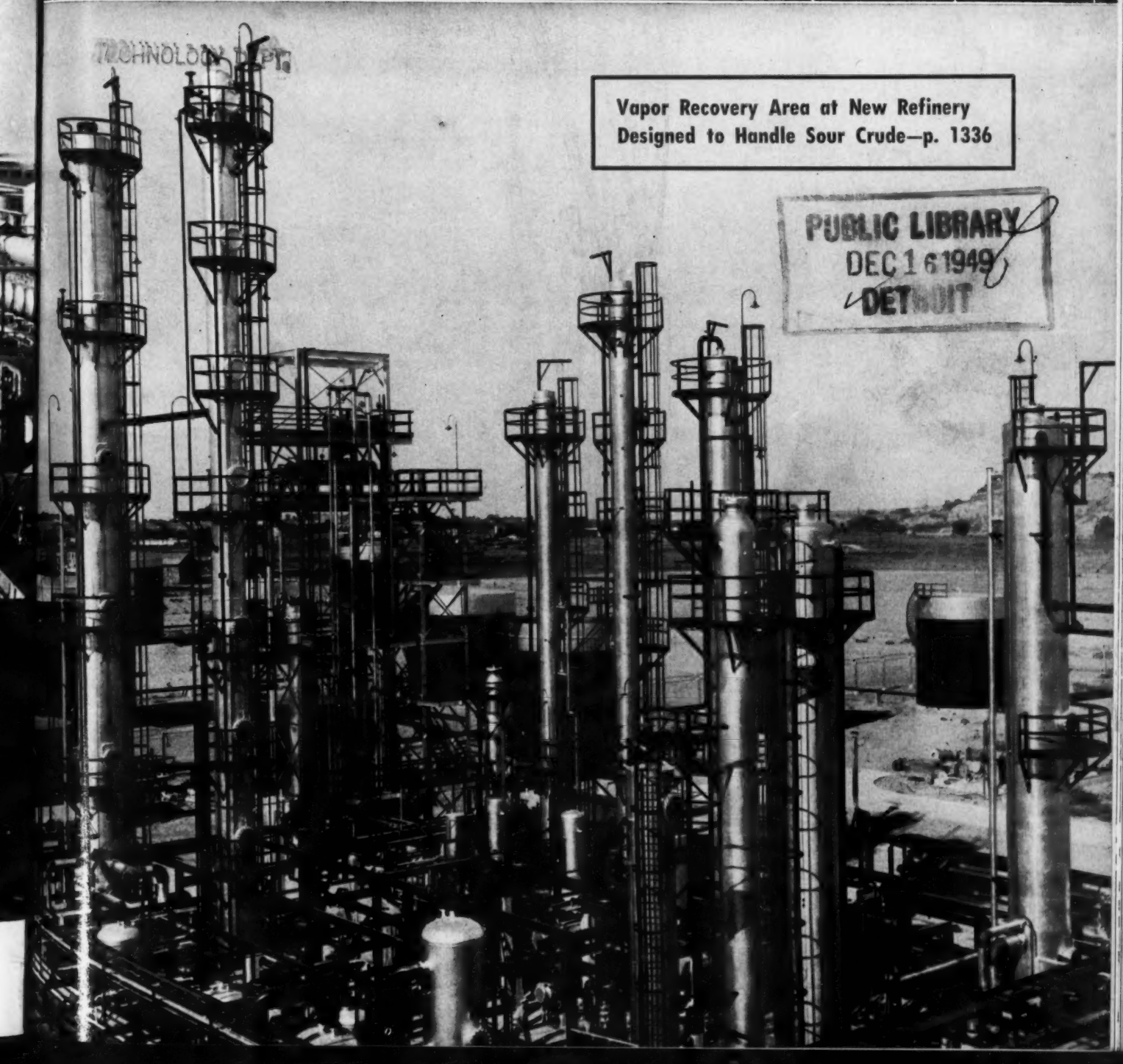
DECEMBER, 1949
VOL. 4, NO. 12

PETROLEUM PROCESSING





Vapor Recovery Area at New Refinery Designed to Handle Sour Crude—p. 1336

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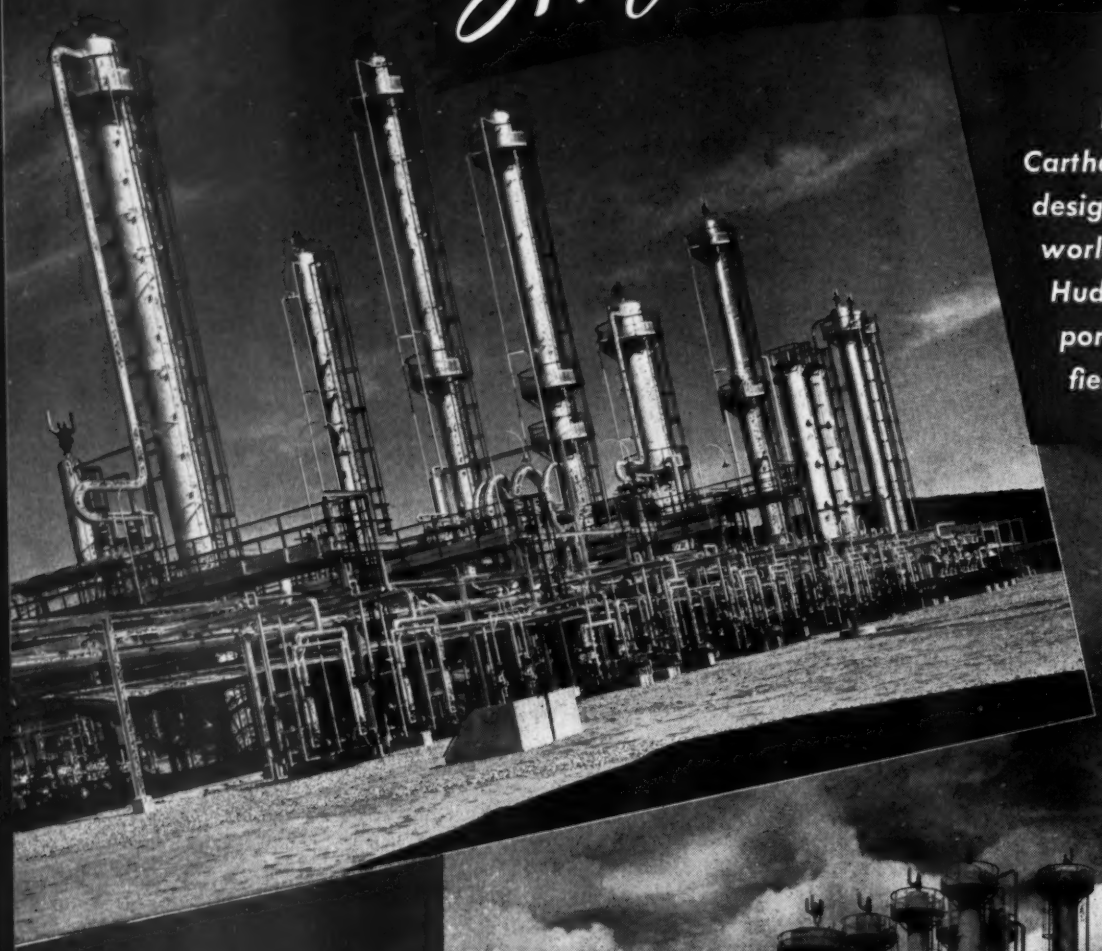
DETROIT

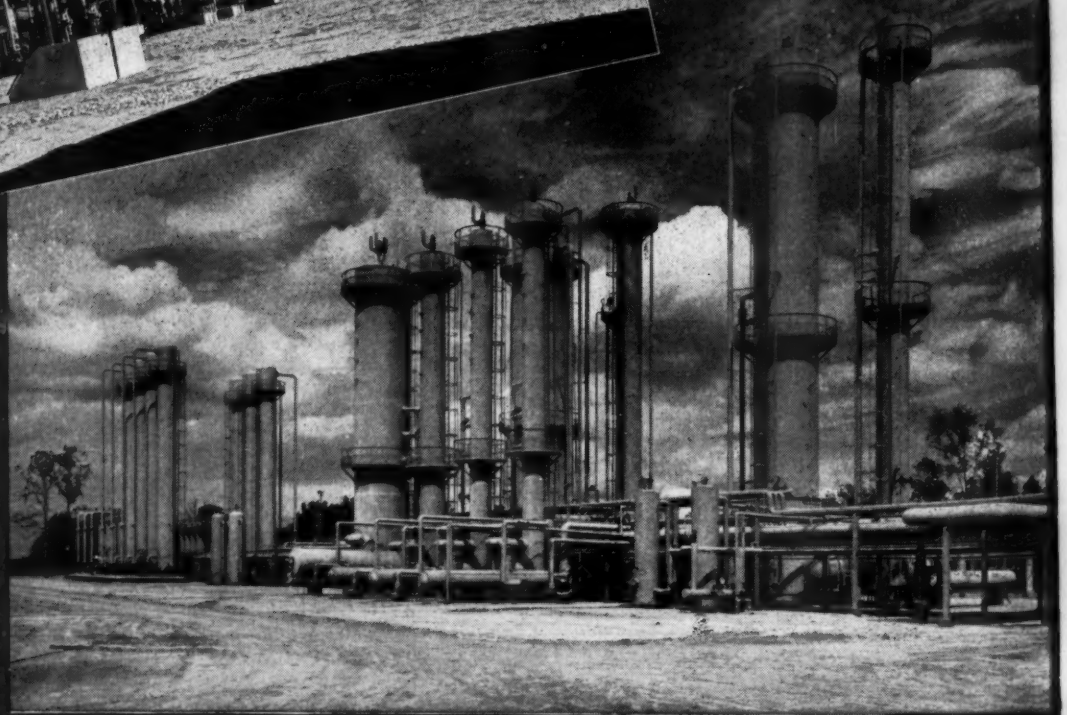
At Home or Abroad

REGIE AUTONOME DES PETROLES



In Boussens, France or Carthage, Texas, HUDSON-designed plants justify the world-wide reputation of Hudson Engineering Corporation as leaders in the field of gas processing.

THE CARTHAGE CORPORATION



Pictured above are two HUDSON-designed plants . . . each processing gas to extract propane and heavier hydrocarbons and water vapor from gas entering cross-country pipe lines. The Carthage Corporation plant, largest of its kind in the United States, is installed at Carthage in East Texas. The French plant, owned and operated by Regie Autonome des Petroles, processes gas from the St. Marcet gas-distillate field, in the foothills of the Pyrennes mountains. This is the largest gas processing plant in Europe.

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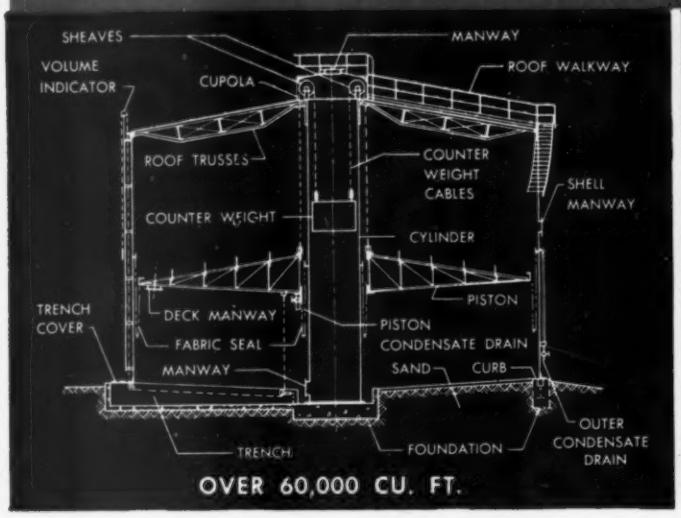

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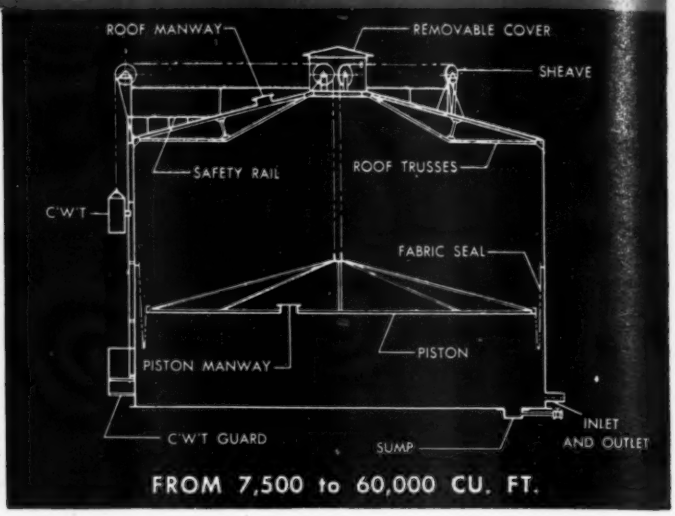

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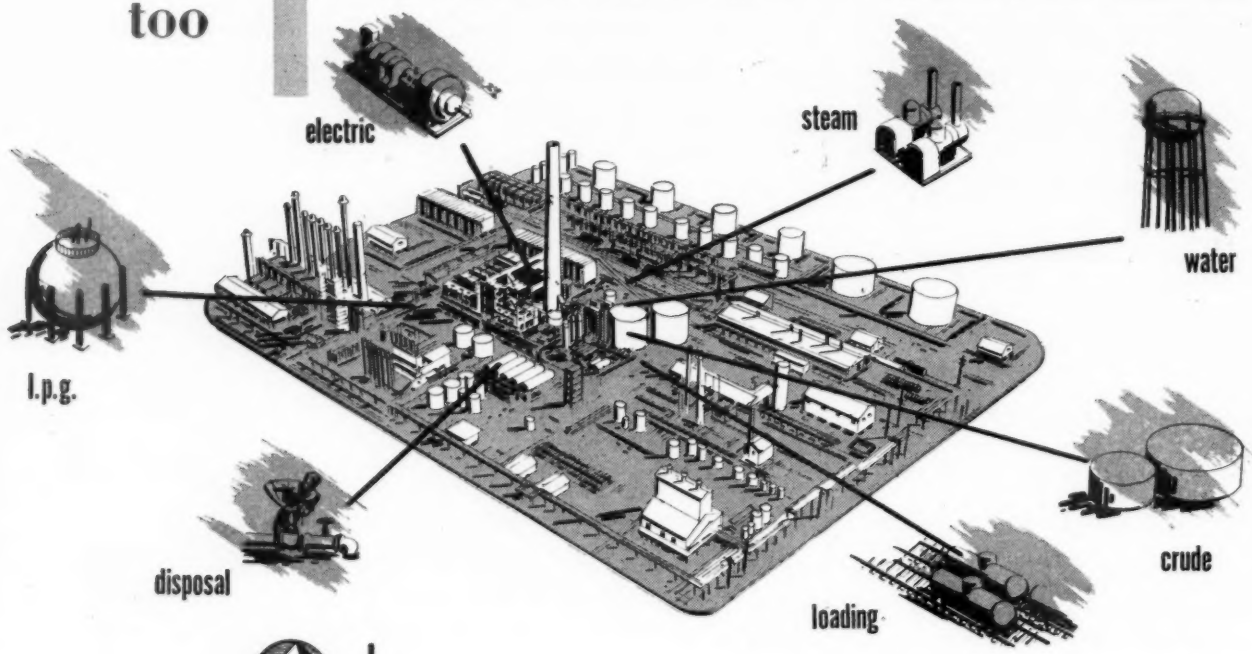

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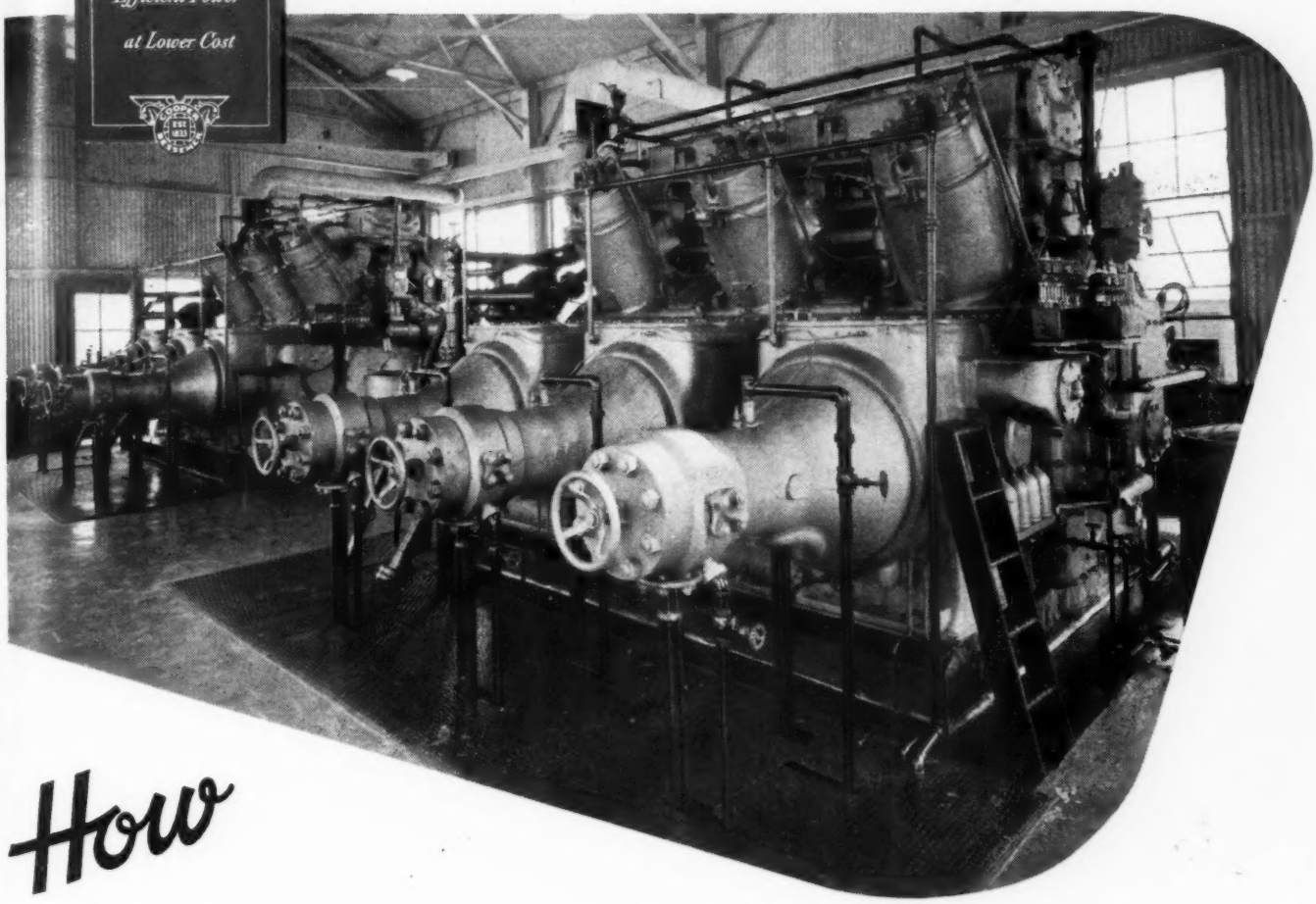

How GMV compactness and durability pays off

for Western Natural

The two Cooper-Bessemer GMV compressors you see here have outlived the cycling requirements in one field . . . and are now doing an efficient job in a new location. Installed eight years ago at Edinburg, Texas, they were recently transferred by Western Natural Gas Company to handle the compressor requirements at their new Goebel cycling plant in Live Oak County, Texas.

This "case history" is significant. First, it testifies to the long, efficient life of these modern Cooper-Bessemer V-angles — units that obviously are ready for many more years of trouble-free, low-cost operation. Secondly, it emphasizes the advantage of GMV compactness — compressors that are installed, housed, operated and maintained at exceptionally low cost.

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What's Happening!

Important Current News Summarized for Refiners

COMPLETIONS

Shell Oil Co. has completed a maintenance building having 98,000 sq. ft. of floor space at its Houston refinery. It is capable of handling $4 million worth of maintenance work annually, and all plant maintenance operations will be consolidated in the new 1-story structure.

MFA Oil Co. has completed a 1000 b/d Perco cycloversion unit at its Chanute, Kans., refinery for desulfurizing and reforming cracked gasoline. Koch Engineering Co. designed the unit.

Union Oil Co. of Calif. has completed a 6000 b/d Duo-Sol unit at the Oleum, Calif., refinery, with Max B. Miller Co. in charge of engineering and construction. Also completed are asphalt and refined oil loading facilities. Still under construction are revisions of crude facilities and utilities, compounding and barreling house improvements, plus additions to offices, shops and miscellaneous buildings, to be completed in December; fuel oil tankage and transfer facilities are scheduled for early 1950 completion.

Full scale operations are expected to be under way by or before mid-December at The Texas Co.'s West Tulsa refinery, signaling completion of the $25 million expansion program started early in 1948. New facilities increase plant capacity to 30,000 b/d and include 15,000 b/d fluid cracking, polymerization, furfural solvent extraction, new boiler house and other auxillaries. Contracts were held by M. W. Kellogg Co. and Foster-Wheeler Co.

• • •

MARKETS, PRICES

November proved one of the most uncertain months of the year from the refiner's viewpoint. Warm weather in the nation had backed up distillates to extent that "voluntary discount" were resorted to by some marketers to move unwieldy stocks. Slow-moving fuel oils had their effects in reduced demand for crude. Gasoline prices turned downward in all areas.

Toward the end of the month, however, there was a marked upswing in demand for heavy oils, and distillates appeared to be moving better. Firming tanker rates tended to "tighten up" some of the soft spots along the East Coast, notably New York harbor.

Main problem was how to inject life into the distillate market, for warm weather held back demand in all areas. Storage was filled.

Reduced demand for distillates caused sharp cutbacks in manufacturing, particularly in Texas, where the drop in refining amounted to about 10% of rated capacity. Of 14 Independent refiners on the Gulf Coast, only three were operating at near-normal capacity; seven were shut down.

Immediate result was a marked easing in supply of crude oil in Texas. Offerings for outright sale were plentiful with few takers. There were reports of some newly-completed wells being shut in pending improved demand. Some trade sources were of the opinion that cut of about 10% in Texas oil allowables for December staved off an early decline in crude prices. December and January allowables also were reduced in Oklahoma.

Refiners generally continued to comprise the least happy segment of the industry. The squeeze between crude prices and product prices showed few signs of widening, for gasoline prices declined more rapidly than fuel oil prices went up.

Decline in gasoline prices was general throughout the country. East Coast majors reduced prices during the last week of the month in amounts ranging from 0.1 to 0.7c per gal. Gulf Coast cargo prices were off 0.25c for most grades. Grade 100/130 aviation gasoline was qouted at 16c; regular-grade, 79 Research, at 9.25c; 83 Research at 9.5c.

End-of-month developments, however, brought a measure of optimism to refiners. There was a rapid upsurge in demand for heavy oil generally throughout the Midwest, and some refiners ceased offering in open market. Firming tanker rates contributed to some strengthening in Bunker "C" fuel oil prices along the East Coast. There also was some increase in demand for No. 2 fuel.

EXPANSION

Standard Oil Co. of Ohio will spend $4.5 million converting present Houdry fixed-bed catalytic cracking facilities at its Cleveland No. 1 refinery to a moving-bed unit, and boosting throughput to 18-22,000

Information on these pages is obtained through the nation-wide news coverage services of PLATT'S OILGRAM NEWS

b/d from present 12,000 b/d. Construction plans are being prepared by Sohio engineers.

Socony-Vacuum Oil Co. has authorized a light oil treating unit of 28,000 b/d capacity at its Paulsboro, N. J., refinery. S-V also will convert a 15,000 b/d Houdry cracking unit to TCC at Trenton, Mich., and a similar unit at Augusta, Kans. Work has not started on any of these projects.

Magnolia Petroleum Co. has awarded Lummus Co. the contract for converting two 15,000 b/d Houdry units to TCC at its Beaumont, Texas, refinery. Completion is expected late in 1950.

Evangeline Refining Co. is installing a 400 b/d single-chamber Perco cycloversion unit for its Jennings, La., refinery which will be completely fabricated in Houston by Mason Bros. Construction Co. and shipped as a "package" unit. Grebe & Doremus Process Co. designed the unit.

McMurrey Refining Co. will build a Fluid cracking unit, with gas recovery, feed preparation and cycle oil cracking facilities at its Tyler, Texas, refinery. Completion is scheduled for next fall and climaxes the expansion and modernization program started 18 months ago. Contract has not been awarded.

Johnson Oil Supply Co., Gary, Ind., plans to add thermal cracking to its facilities, and to increase present 4000 b/d capacity to 5000 b/d. A new asphalt tower was recently installed.

British-American Oil Co. is planning a 5000 b/d refinery near Edmonton, Alberta, with construction to start next spring. Contracts have not yet been let.

• • •

TRANSITION

Chicago Corp. has purchased refining and pipe line facilities of Atlas Oil & Refining Corp. at Shreveport, La.; will take possession Jan. 1. Chicago is acting for a group of companies which will take over facilities under a new name but retain present management. Plant is rated at 12,000 b/d and will be expanded to include processing of distillate stocks from one or more gas plant operations in which group has interests.

Premier Oil & Refining Co. has closed its 8000 b/d lube plant at Ft. Worth "temporarily" because "there is no money in the lube business with market prices as low as they are."

Petrol Refining Co. has shut down its 60,000 b/d refinery at Texas City, Texas, which has been running at half capacity because of price squeeze between crude and refined products prices.

NATURAL GASOLINE

Part of the Levelland gasoline plant near Levelland, Texas, operated by Stanolind Oil & Gas Co. for nine other owners began operating Nov. 8. Completion of absorption, distillation and fractionation sections is scheduled for Feb. 1; meanwhile compression gasoline is being shipped to Stanolind's Slaughter plant, 15 miles away. The finished plant will handle 40,000 Mcf. of gas daily, produce more than 130,000 gal. of liquid hydrocarbons.

The Burnell-North Pettus cycling plant near Pettus, Texas, which Stanolind also operates for 19 other owners, now is in operation. Plant handles 166,000 Mcfd. of gas, selling 30,000 Mcf. to pipe lines and returning the balance to producing formations; produces more than 330,000 gal. per day of liquid hydrocarbons, of which about half is natural gasoline.

Cities Service Oil Co. has completed modernization and expansion of its Pampa, Texas, plant, now rated at 18,000 Mcfd. of gas, from which can be produced 35,000 gal. of natural gasoline and butane and 25,000 gal. propane daily. To be completed by Christmas is the company's Chico plant, 45 miles from Ft. Worth. Plant is designed for an ultimate capacity of 22,500 Mcfd. of gas, yielding 60,000 gal. total of hydrocarbon liquids, with installation of additional equipment.

• • •

FOREIGN

Anglo-Iranian Oil Co. has completed a 40,000 b/d crude distillation unit which almost trebles throughput of its Llandarcy, S. Wales, plant. This is part of the expansion program there for which ECA recently furnished $7,250,000.

Economic Cooperation Administration has agreed to underwrite $2 million of the estimated $6.4 million cost of expanding and modernizing the Porto Marghera (Venice), Italy plant of Societe Raffinazione Olli Minerali. Crude capacity will be doubled, to 22,000 b/d, and facilities installed for lube manufacture.

Deutsche Shell Oil Refinery, Hamburg, Germany, now is back in operation after being 90% destroyed during the war. It will process 8800 b/d of crude, producing gasoline, lube oils and allied products.

Refinery projects already started or on which work soon will commence assure Western Europe of a crude throughput capacity of 1,020,000 b/d, or but 40,000 b/d short of the total Economic Cooperation Administration is said to regard as the top limit of a program it can reasonably go along with. ECA is said to be actively considering 40,000 b/d of projects to hit its arbitrary ceiling of 1,060,000 b/d.

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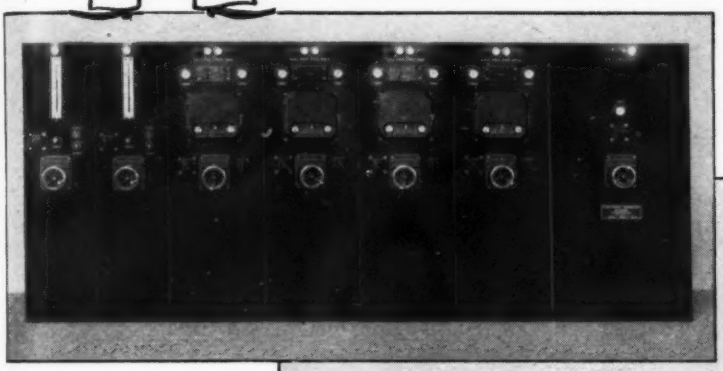
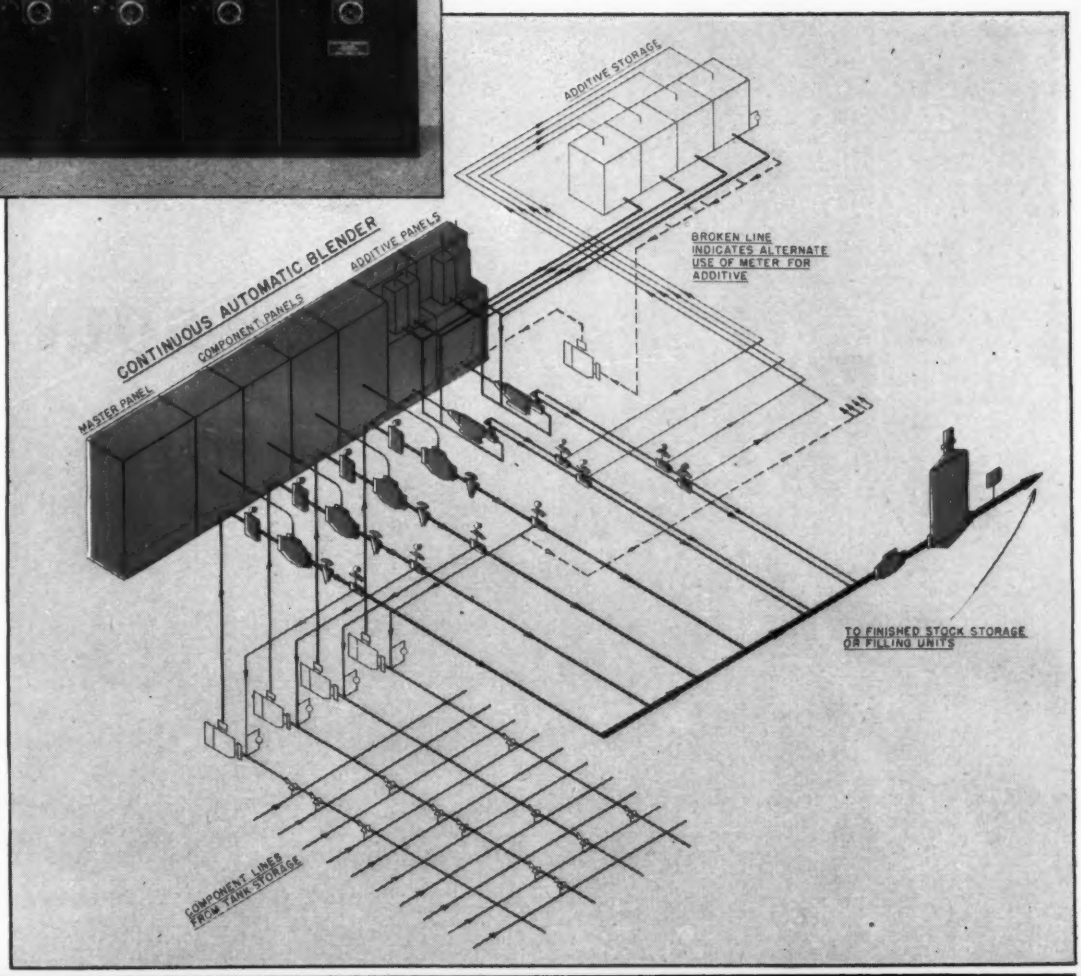


Typical blender panel arrangement for four base stocks and four additives. Since each additive and component control panel is a complete unit in itself, additional panels can be readily incorporated in the assembly at any future time.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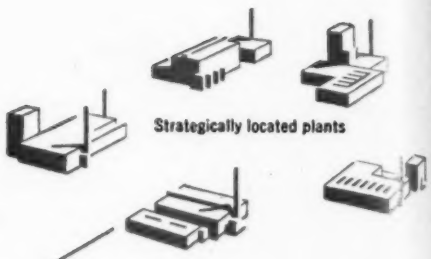

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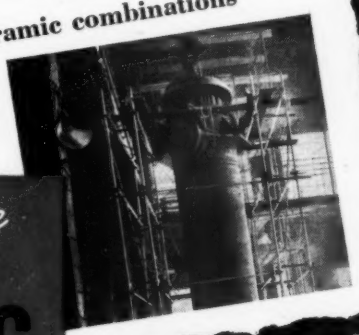

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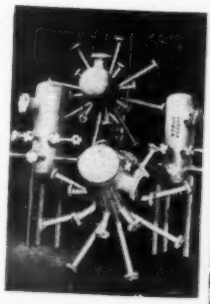

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Tomorrow
. . . IN PETROLEUM TECHNOLOGY

By B. H. WEIL, Atlanta, Ga.
Editor, "Monthly Summary of Industrial Developments"

Brief reviews of currently reported technological and economic developments, in the light of their potential bearing on petroleum refining

Adsorbent Developed For Re-Refining Oils

AS recently shown by Census of Manufacturers figures for 1947, re-refining operations in the U. S. have increased rapidly in recent years—420% from 1939 to 1947 as regards value of products shipped by re-refiners. The figure probably does not include the large volumes of lubricants re-refined by oil users themselves, or by the Armed Forces, especially the Air Force.

While the terms "re-refining" and "reclaiming" have been used interchangeably in much of the early literature in this field, it now appears that those companies which use combination processes that approach or equal refining in complexity are carefully stressing a difference, one which is of considerable importance as regards quality. "Reclaiming," according to a recent Filtrol Corp. booklet,(1) usually involves only the removal of visible impurities by filtration or centrifuging, methods which do not satisfactorily remove such harmful impurities as moisture, tars, resins, cracked products, etc.

"Re-refining," however, is said to make possible restoration of the used oils to their correct specifications by (1) "fractional distillation to yield products of the proper viscosity or fluidity for maximum lubrication" and (2) "the removal of unstable substances, those which tend to emulsify or oxidize in service, or interfere with the durability and finished appearance of the oil."

According to this booklet, the latter step may be satisfactorily effected by adding to the distilled oil an adsorbent such as Filtrol's "Retrol," which is said to be superior in performance to natural earths in purifying, decolorizing, and fast filtering properties. Following mixing, the adsorbent-containing oil is then filter pressed to remove the adsorbent-impurity fraction as filter cake.

The advantages of using highly active adsorbents such as Retrol are said to be higher filtration rates, lower oil retention in the filter cake, excellent color and fluorescence restoration, etc. Smaller quantities of adsorbent can be employed than when using low-grade materials.

The value of products of lubricants shipped by re-refiners in 1947 amounted only to slightly more than 0.1% of the total value of products shipped by companies refining new oils in that year. However, it must be borne in mind that re-refining operations are increasing. It is important to the petroleum industry, whether or not it recognizes re-refining as a branch of its operations, that lubricants on the market be—as a minimum—noninjurious for use under normal conditions, so it is encouraging to note that attention is being given to the provision of quality materials for use in re-refining processes.

New Alloy Cast Irons For Refining Equipment

TO those who must specify materials for refinery and equipment construction, the never-ending research being conducted in the metallurgical field by companies which sell alloys and specially treated metals is always of particular interest, since it means that the balance between first cost and service life is continually shifting, also that economies may suddenly become possible through use of entirely new materials.

For example, a paper(2) presented before the ASME in Oklahoma City, Oct. 3-5, calls attention to the possibilities of using the new special-service types of alloy cast irons in applications where more expensive steels have previously been employed. For many years—up to about 1920—"cast iron was a low-tensile-strength metal that was easy and cheap to produce, but with the technical advances that have been made in the last 30 years—the use of alloys, control of foundry practices, etc.—the range of properties available today in cast irons has been greatly widened."

In his above-mentioned paper, Sefing points out that the proper microstructure must be developed in a cast iron if metal-to-metal wear is to be minimized. Abrasive wear can be reduced by incorporating small percentages of nickel and chromium in the white cast iron to increase hardness. Graphite-containing, carefully specified gray iron is said to give better service life than steel in many applications involving vibration damping capacity and toughness.

In connection with this latter property, Sefing remarks that a new process developed by his company now makes possible the production of cast irons "with strength and toughness levels in excess of those found in malleable iron." This process "involves the addition of magnesium to the iron, resulting in the spheroidal graphite form instead of the well known flake form." Moreover, the cast irons produced can be employed in high-temperature service at 1300° F. or more, compared to the 800-1000° F. maximum for gray irons.

While plain cast iron can be employed only in mildly corrosive atmospheres, the new chromium- or nickel-containing alloys "have found wide usefulness in many applications in the petroleum industry—handling acids, alkalies, salts, sea water, acid crudes, etc." Combined resistance to corrosion and abrasion may be obtained from an alloy also containing some copper, when properly quenched. Moreover, some of the newer alloys have excellent properties at subzero temperatures.

Sefing lists such petroleum refining equipment as engine cylinders (for compressors, etc.), pumps, valves, headers, cooling equipment, acid sludge lines, coke handling and pulverizing equipment, and dewaxing filters as capable of being fabricated economically from properly selected cast irons.

Acetylene from Petroleum Nears Commercial Reality

ACETYLENE has long been a chemical building block whose synthesis from paraffinic hydrocarbons (natural gas or petroleum) has intrigued those interested in or involved in the synthesis of chemicals from petroleum. High-temperature pyrolysis under controlled conditions and electric arc "cracking" have both been explored extensively as methods of synthesis, and reports have been current for several years that one or both methods would soon be commercially employed. Rumor has it that at least one of these processes *is* in use, but there have been no substantiating details.

On a large scale and with favorable power costs (for synthesis of the calcium carbide), acetylene re-

portedly can be produced by the well known carbide process to sell at 6-9c lb. Exact costs for synthesis from petroleum or natural gas are unknown, although one source recently estimated a figure of 6-7c lb. for high-purity acetylene produced by pyrolysis, in Texas.

As mentioned several years ago in this department, one of the companies which has admitted considerable interest (through publications, etc.) in the synthesis of acetylene from paraffin hydrocarbons by high-temperature regenerative cracking is the Tennessee Eastman Corp. It is therefore highly significant to note that this company has announced plans to erect a multi-million-dollar plant at Longview, Texas, for the manufacture of basic materials for use in its Kingsport, Tenn. plant, and that it is reported that "acetic anhydride will be made from ethane via acetylene."(3)

According to one report, the cost of the first unit will approximate $1,-500,000, but another source states that "initially, about $4,000,000 will be shelled out on a plant that is expected to be operating late in 1950. But this unit will occupy only a few of the 2300 acres that Tennessee Eastman has acquired. . . Construction of a rayon plant at Longview, to turn out cellulose acetate, is a long way off."

Acetylene is being employed for the synthesis of many chemicals also derivable (potentially or actually) from ethylene. The comparative economics of both basic materials are very close in many cases, but in some cases low-cost acetylene holds a definite edge. It may well be expected that several plants using petroleum hydrocarbons or natural gas for the synthesis of acetylene will be constructed in the next few years, provided economic conditions do not raise unexpected barriers.

Polyethylene Finding Wider Applications

POLYETHYLENE plastics, among the newer of the plastics produced from petroleum hydrocarbons, are of considerable interest to users and bystanders. Produced by polymerizing ethylene catalytically under very high pressures, these materials have many properties which render them useful for commercial and consumer applications. That these properties are being properly appreciated may be judged from the following excerpts from a *Modern Plastics* editorial:(4)

"Over 23,000,000 polyethylene squeeze bottles have been produced in the past two years. More than 100 products are currently using this package. . . When a relatively costly plastic, first produced commercially only six years ago, can move into markets and take sizable chunks of business away from glass — the cheapest material ever made by man —the situation merits more than passing notice. The reason is obviously in the superior functions of the plastic. The polyethylene bottle is unbreakable, inert, tasteless, odorless, and nontoxic. It can handle caustic chemicals and problem acids in its stride. It has a pleasant 'feel.' It is so attractive and so durable that some companies using it as a package make savings by omitting the customary cardboard carton.

Incidentally, the first polyethylene resin, "Polythene," was originally developed in England, where the production of chemicals from petroleum is only now coming into commercial reality. In a recent speech, Dr. Robert S. Aries, a New York consulting engineer, pointed out that increased production of petroleum throughout the world is hastening the day when other countries will be in active competition with U. S. petrochemical manufacturers and may even be able to export such products to this country because of lower costs, including labor.

That this day will not come soon is apparently the current view, however, for Dr. Gustav Egloff, director of research of the Universal Oil Products Co., recently pointed out that over $1,000,000,000 is currently being spent on the construction of chemical plants which will use petroleum as raw material.

In any case, the petroleum industry will always be interested in products produced from ethylene, and among these the polyethylene plastics are current jewels.

Patent Uncertainties Posed by German Data

THE petroleum industry has been more than interested in the flood of reports on German technology made available through the Office of Technical Services, the Bureau of Mines, and other groups. As will be remembered, its chemists and engineers played an active role in the teams which went to Germany even before the end of hostilities in order to obtain pertinent data. Petroleum company librarians, information groups and research men are still actively engaged in translating German records and searching through the tons of material available for data on processes and products of direct significance to present work.

Just as every cloud is said to have its silver lining, however, so every bonanza contains its share of "fools gold." As pointed out by Col. Harry A. Kuhn, USA (ret.), at the recent Atlantic City ACS meeting, "a by-product of this tremendous fund of German technical information may appear in the form of patent uncertainties. The lack of an adequate index prevents a thorough search of the literature, and this can have a diametrical effect. It can cast doubt on the validity of issued patents, or act as a bar to the issuance of a patent based on independent research in this country."(5)

There is no easy solution to this problem. Even cooperative effort directed at definitive indexing of *all* this information would involve vast sums. All that each company can do is to use every available key to the data to which access can be had. As regards synthetic fuels and petroleum chemicals in particular, this is not a pleasant situation.

Atomic Energy Still Some Distance Away

PHILLIP Sporn, president of the American Gas & Electric Corp. and chairman of the advisory committee on cooperation between the electric power industry and the Atomic Energy Commission, recently told the National Coal Assn. that it will be 15-25 years or more before atomic fuel presents a significant competitive threat to coal. According to Sporn,(6) "estimates of the cost of nuclear power run all the way from $140 to $1000 per kilowatt," and are said to be largely guesswork. "If some day the guess at the lower limit is realized or bettered, then atomic power will have great social and economic significance. Even if we can't get costs down to or near the lower limit, it can still have significance in places remote from economical sources of fuel or water power. If costs should stay near or above the very high guesses, then atomic power is unlikely to be used except for such applications as military craft, where cost can be disregarded."

Sporn estimated that the purely experimental phase of the AEC program will take three to five years. "In six to ten years from now, we may have some commercial generation of nuclear power. But I anticipate it will then be commercial only in the sense that it will be operating more or less regularly, day in and day out."

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(1) Anon., *American Industry Speaks—True Experiences With Retrol*, Filtrol Corporation, Los Angeles, 24 pages.
(2) Frederick G. Sefing, "The Basis for Selecting Alloy Cast Irons for the Petroleum Industry." Paper presented before the American Society of Mechanical Engineers at Oklahoma City, Oct. 3-5, 1949.
(3) Anon., "The Chementator — Tennessee Eastman Moves Into Texas," *Chemical Engineering*, 56, No. 10, 74 (1949).
(4) Anon., "Moral in a Plastic Bottle," *Modern Plastics*, 27, No. 2, 5 (1949).
(5) Anon., *Chemical and Engineering News*, 27, No. 40, 2837 (1949).
(6) Anon., *Wall Street Journal*, October 10, 1949, p. 3.

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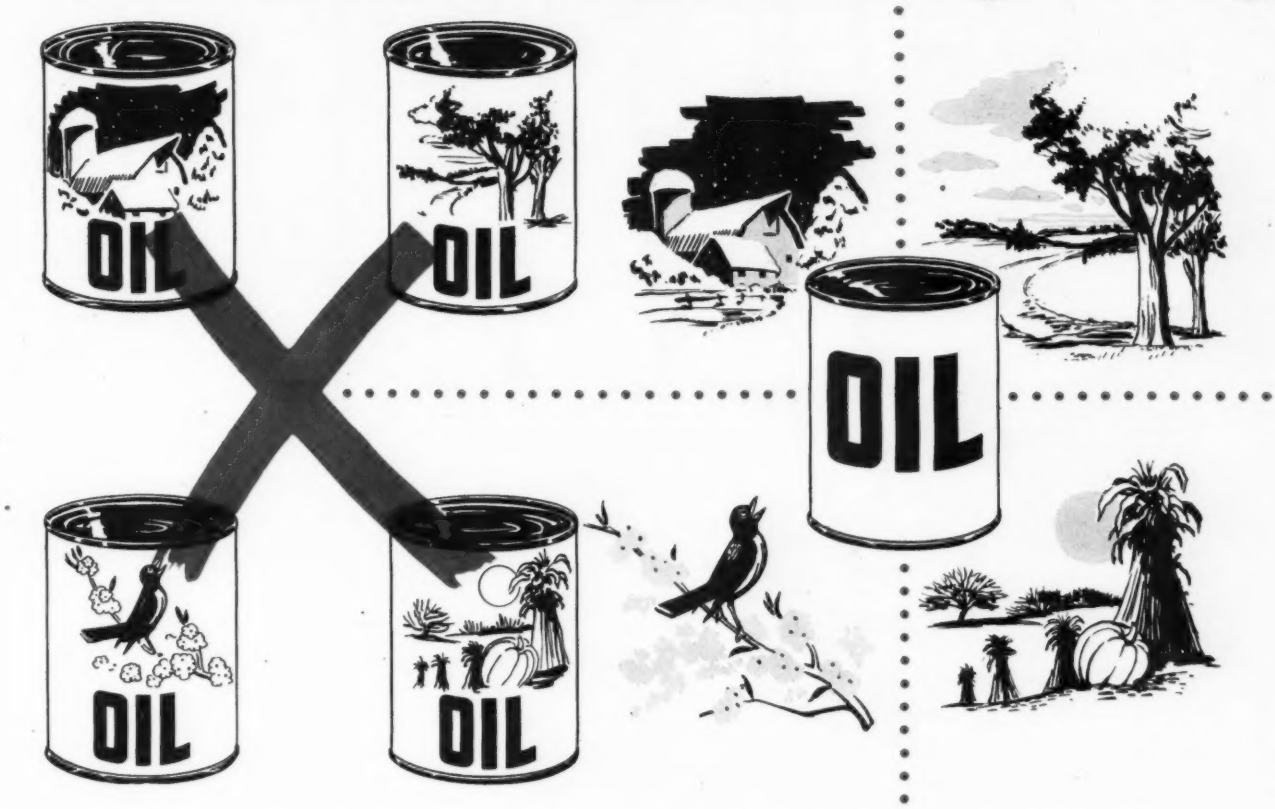

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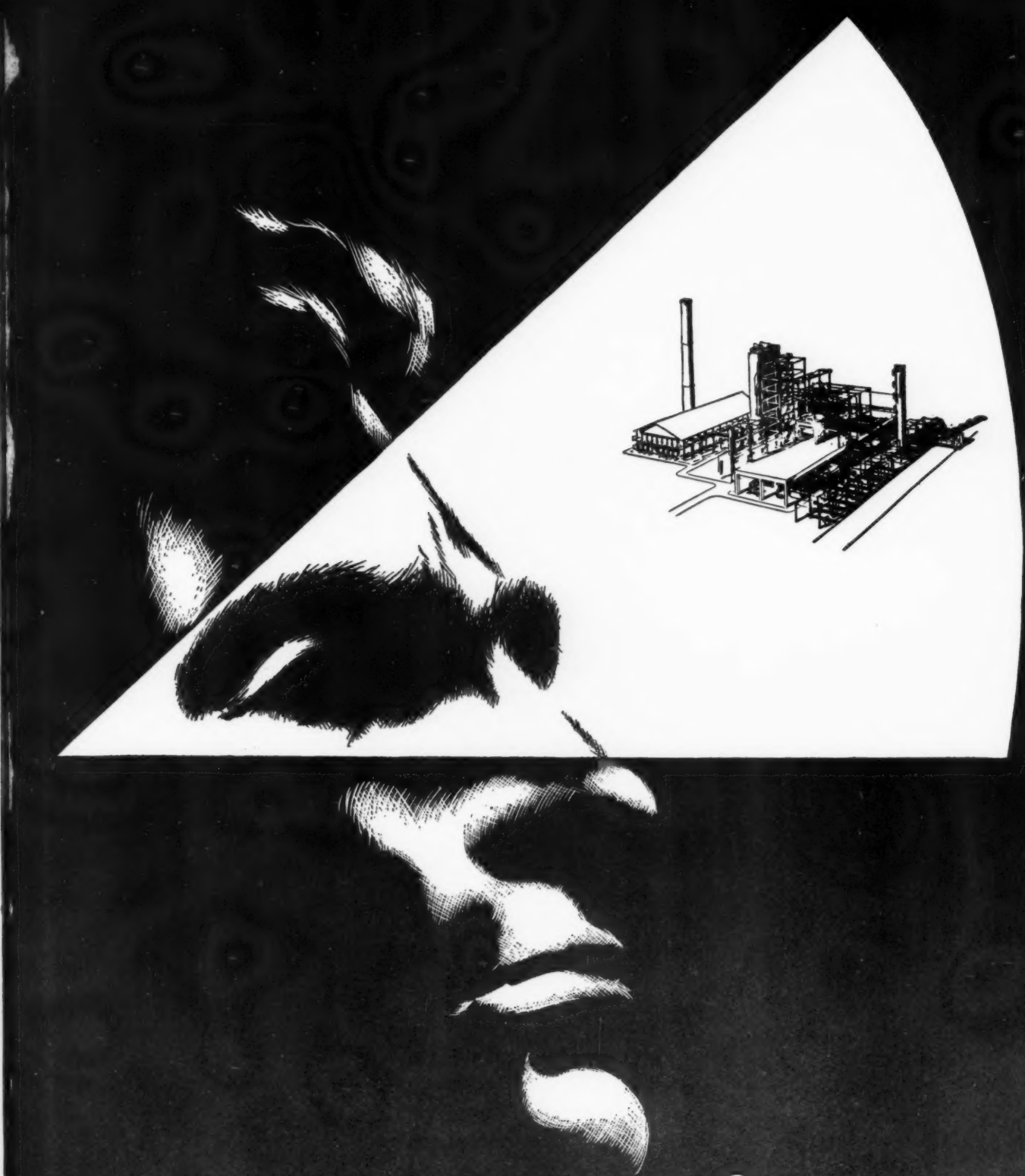

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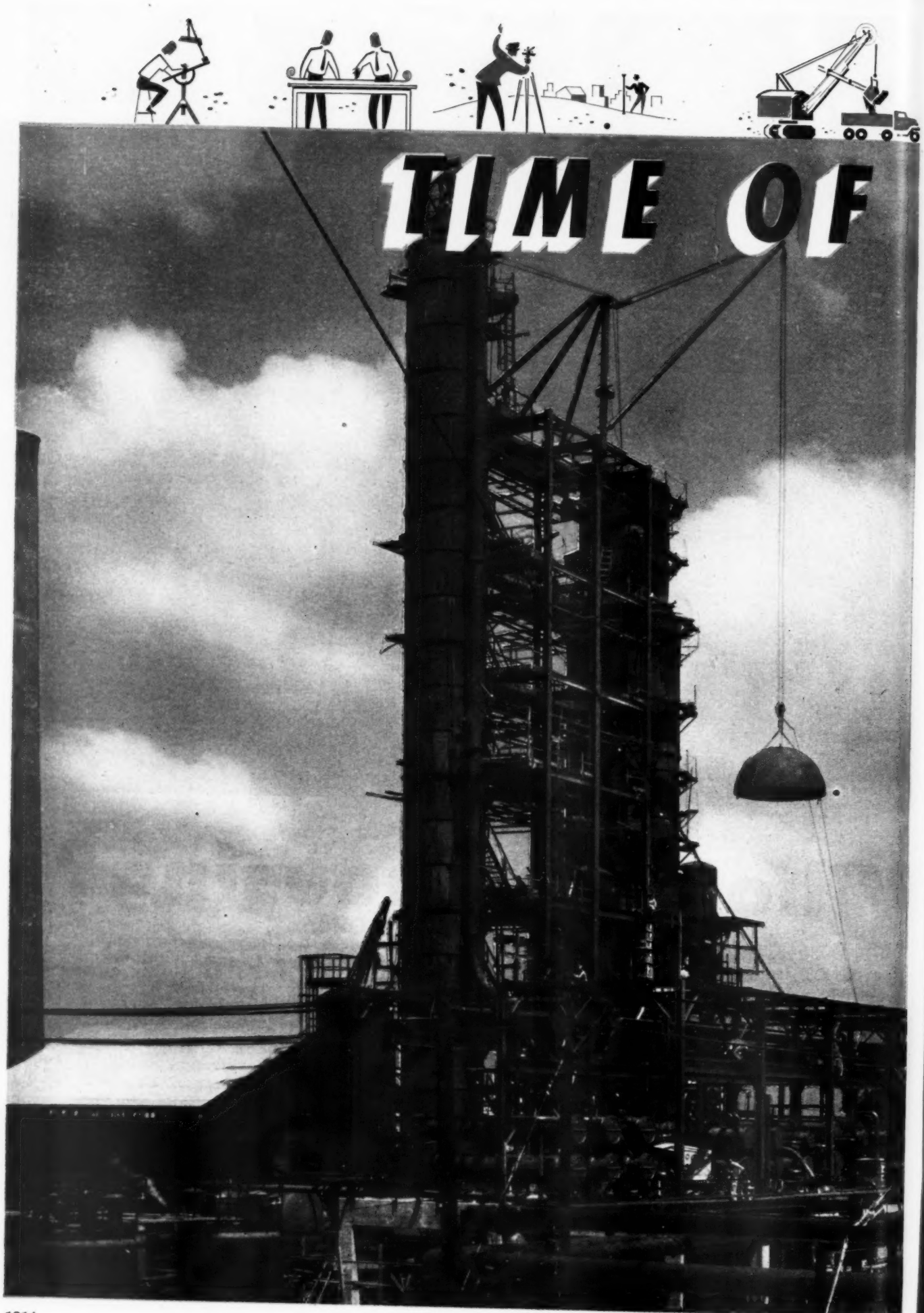
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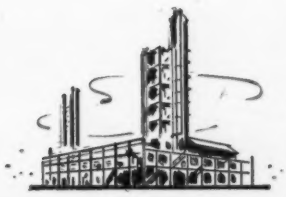

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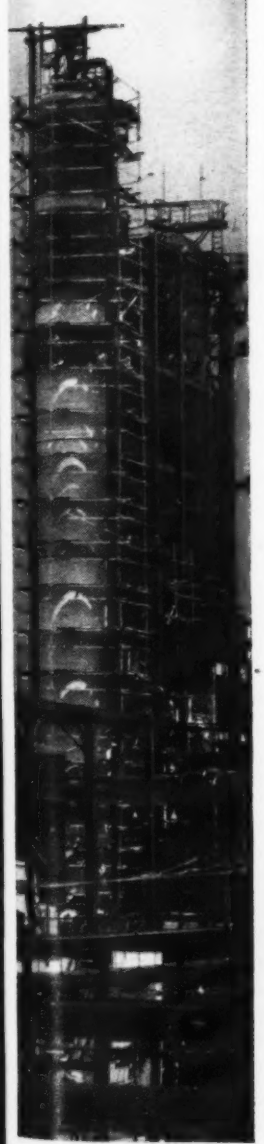

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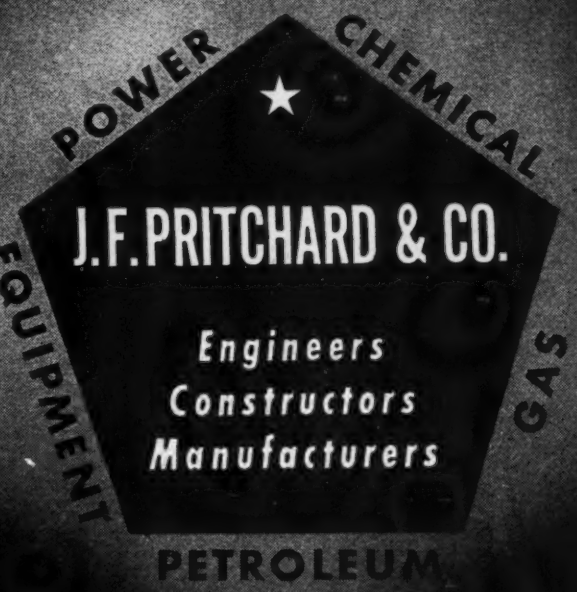

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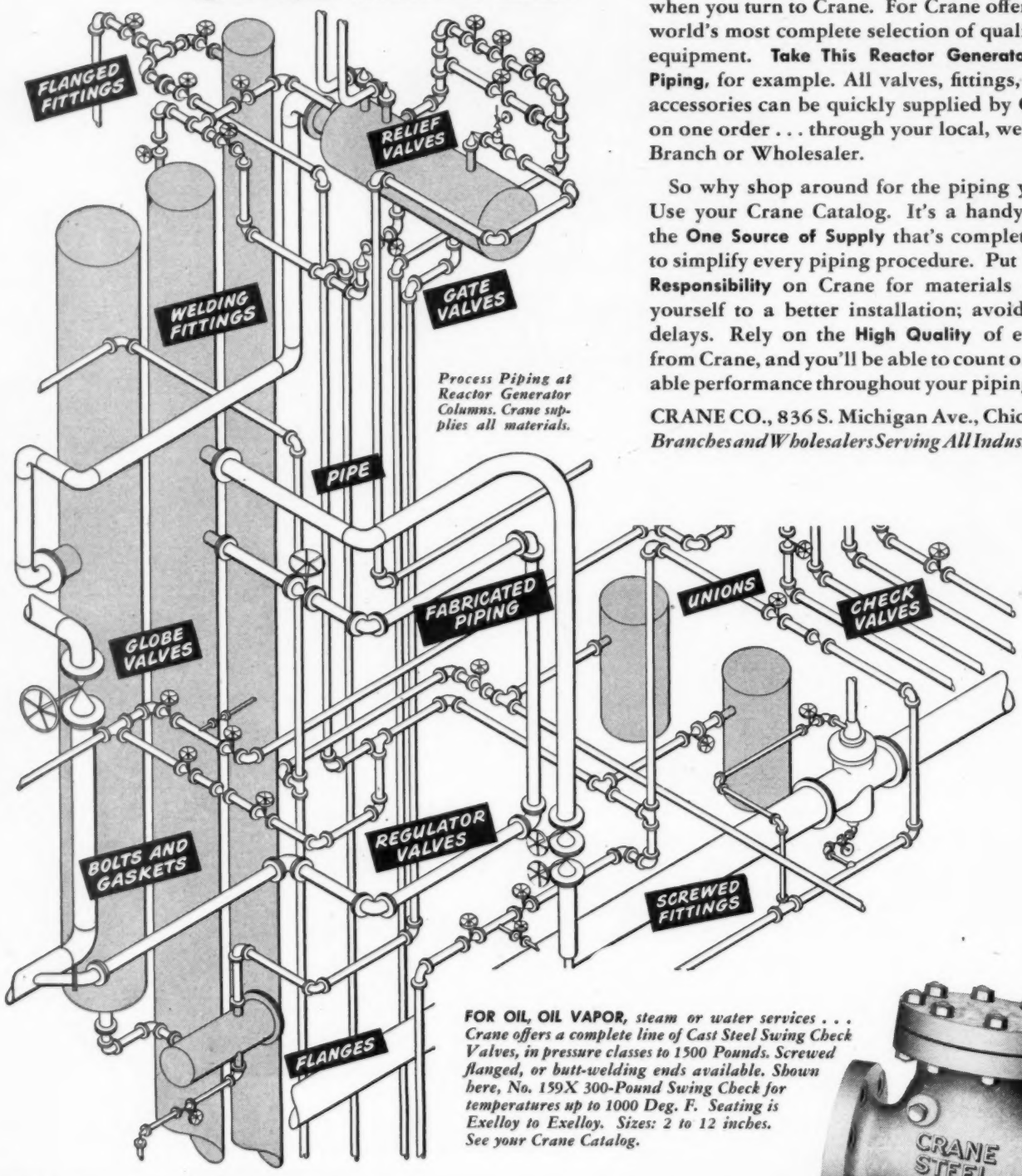

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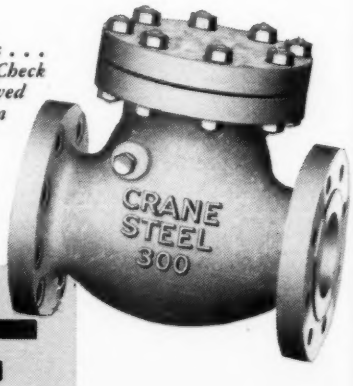

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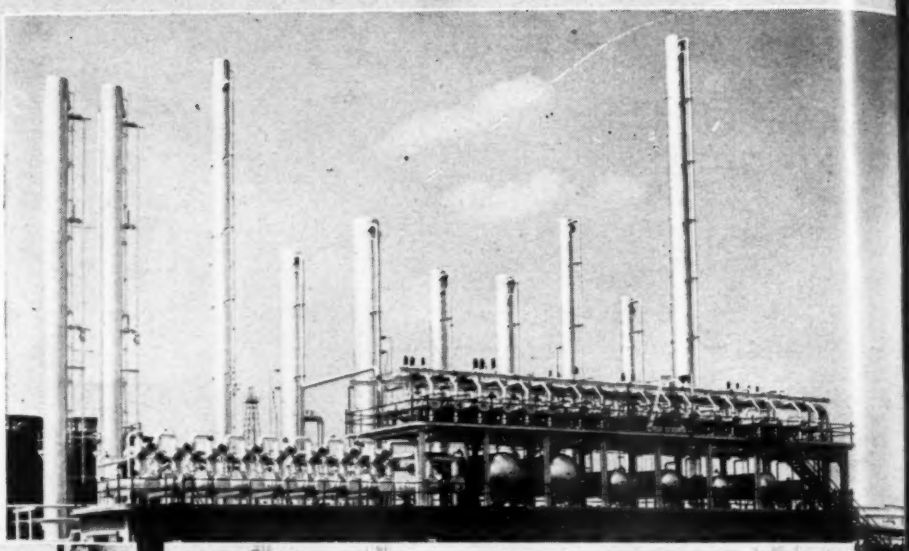
That's the kind of speedy fire protection National AER-O-FOAM provides. AER-O-FOAM forms a quick, thick, tough, airtight blanket of foam that snuffs out flames . . . protects production facilities, refineries and bulk plants. Non-corrosive, it can be washed or brushed off machinery, walls and floors when dry.

For positive fire protection, use FIRE-TESTED National AER-O-FOAM. For complete fire-fighting equipment and engineering assistance, call on National Foam Fire System Engineers.

NATIONAL FOAM SYSTEM, INC.

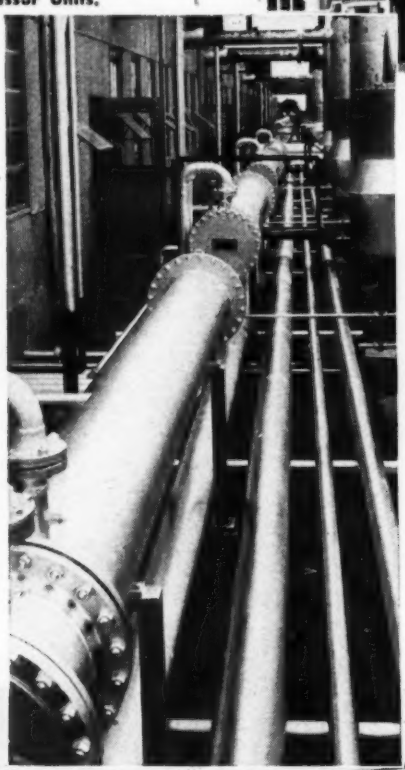
Headquarters for Foam Fire Protection

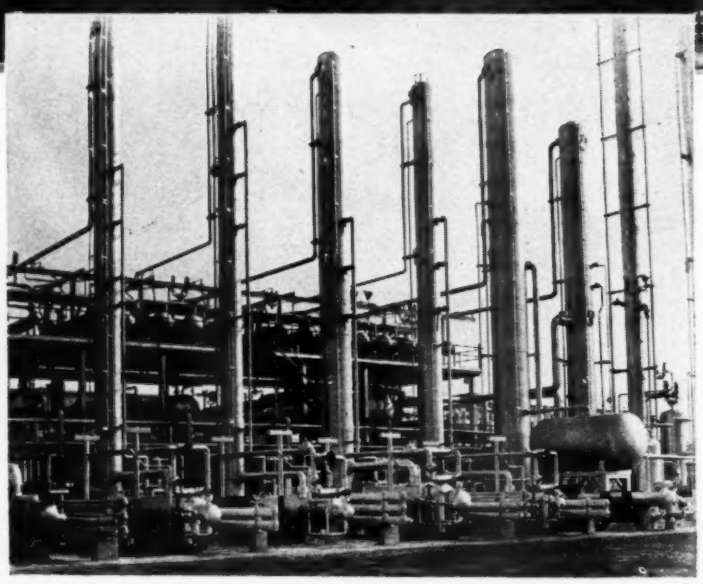
Packard Building, Philadelphia 2, Pa.



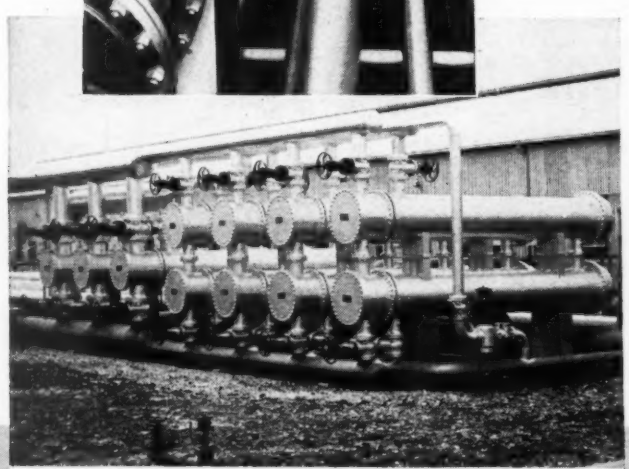
Batteries of G-R Main Still, Primary Still, Deethanizer, Debutanizer, Depentanizer, and Splitter Condensers.

G-R Jacket Water Coolers for Power Cylinders and Compressor Cylinders of Diesel Engine-driven Compressor Units.

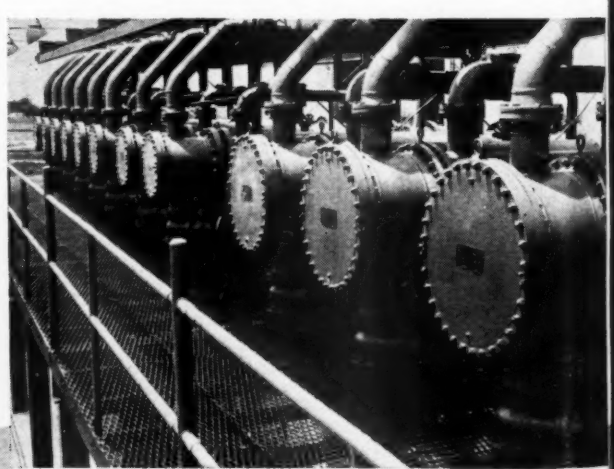




Group of G-R U-Tube Reboilers, and stacks of G-R Twin G-Fin Sections serving as Feed Exchangers and Product Coolers.



Some of the G-R Lube Oil Coolers for the Compressor Units.



Close-up View of the stationary head ends of some of the G-R Condensers shown in illustration at upper right.

GRISCOM-RUSSELL: PIONEERS IN HEAT TRANSFER APPARATUS

NINETY FIVE
G-R UNITS
ON 37 DIFFERENT
HEAT TRANSFER SERVICES
at Stanolind's New Hastings Plant

The Hastings gasoline recovery plant of Stanolind Oil & Gas Company at Alvin, Texas, is one of the many important modern projects in the petroleum industry for which maximum effectiveness and economy of heat transfer are assured by G-R equipment.

The great variety of G-R equipment at this plant, as listed in the column at the right, is significant to you. It means that G-R can furnish exactly the correct type of unit for *any* and *every* heat transfer service. No matter what may be *your* needs for heaters, coolers, condensers or heat exchangers . . . in standard or special designs . . . for moderate or severe requirements . . . you can safely depend on the unequalled G-R engineering experience and performance records. Write for bulletins describing G-R equipment for services in which you are interested.

THE GRISCOM-RUSSELL CO.

285 MADISON AVENUE, NEW YORK 17, N. Y.

GRISCOM-RUSSELL

ROSTER OF G-R APPARATUS AT HASTINGS

2—FST Splitter Condensers

2—Twin G-Fin Section Splitter Feed Exchangers

1—CSU Splitter Reboiler

2—FGT Deethanizer Condensers

2—Twin G-Fin Section Deethanizer Feed Exchangers

1—CSU Deethanizer Reboiler

2—FST Depropanizer Condensers

3—Twin G-Fin Section Depropanizer Feed Exchangers

1—CSU Depropanizer Reboiler

2—FGT Debutanizer Condensers

2—Twin G-Fin Section Debutanizer Feed Exchangers

1—CSU Debutanizer Reboiler

2—FST Depentanizer Condensers

2—Twin G-Fin Section Depentanizer Feed Exchangers

1—CSU Depentanizer Reboiler

3—FGT Primary Still Condensers

3—FGT Main Still Condensers

2—Twin G-Fin Section Propane Coolers

1—Twin G-Fin Section Propane Dehydration Regeneration Gas Reheater

1—Twin G-Fin Section Mixed Butane Cooler

3—Twin G-Fin Section Debutanizer Bottoms Coolers

2—Twin G-Fin Section Isopentane Final Coolers

3—Twin G-Fin Section Gasoline Coolers

4—FST Rich Oil Preheaters

3—Twin Bare Pipe Section Regeneration Gas Coolers

2—Twin Bare Pipe Section Regeneration Gas Heaters

2—Twin Bare Pipe Section Reabsorber Intercoolers

8—FST Main Oil Exchangers

12—FST Compresser Lube Oil Coolers

8—FST Compressor Jacket Water Exchangers

3—FST Engine Jacket Water Coolers

1—H Bentube Feedwater Evaporator

1—F Drainer

1—K Level Controller

3—Twin Bare Pipe Section Steam Condensate Exchangers

2—Twin Bare Pipe Section Condensate Coolers

GR-228

How You Can Cut Costs of RETUBING CONDENSERS

How retubing interruptions can be reduced so you can enjoy longer periods of continuous operation.

How labor costs, usually attending the task of retubing, can be reduced to a mean.

How life of condenser tubes can be prolonged.

How maintenance costs of condensers can be reduced.

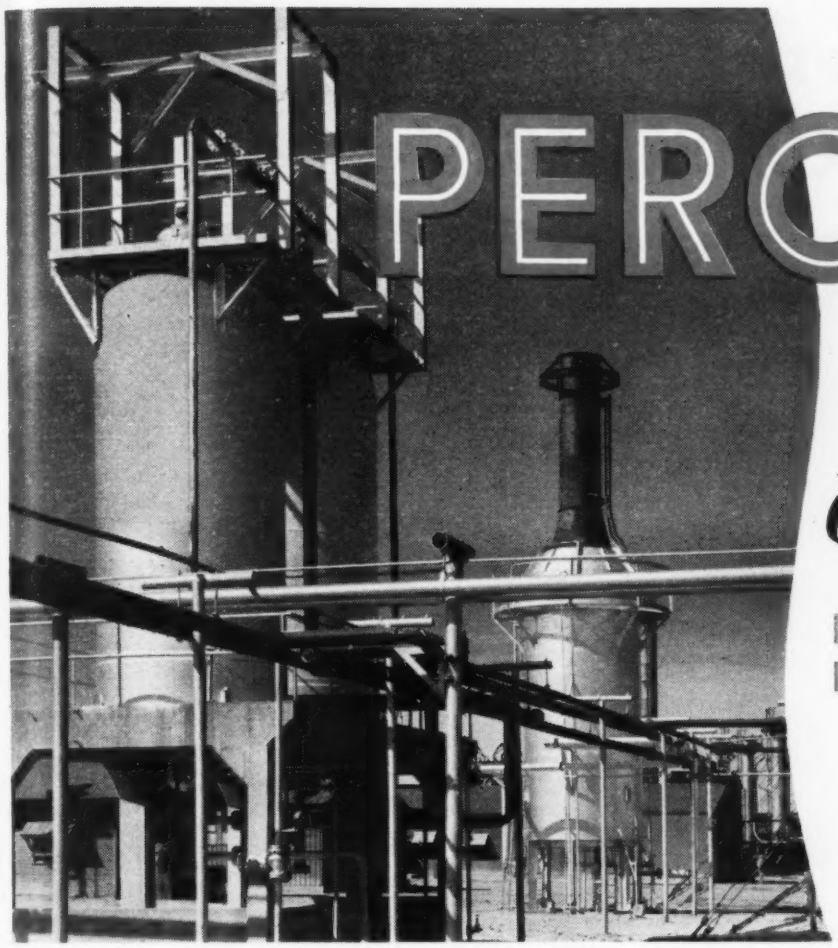
If you want highest efficiency in condenser tube operation for little money—

Specify WOLVERINE CUPRO-NICKEL-30%

You'll quickly realize the economy of using this particular copper-nickel seamless tube, especially if other alloys in the tubes you now have in service are failing because of high corrosive conditions.

Would you like one of our representatives to tell you more about this "different" tube? No obligation, of course. Just call or write us for further information.

WOLVERINE TUBE DIVISION
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
INCORPORATED
MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING
1425 CENTRAL AVENUE • DETROIT 9, MICHIGAN



PERCO*

Octane Insurance

PERCO CATALYTIC DESULFURIZATION

IMPROVES

- **OCTANE RATING**
- **BLENDING VALUE**
- **MARKETABILITY**

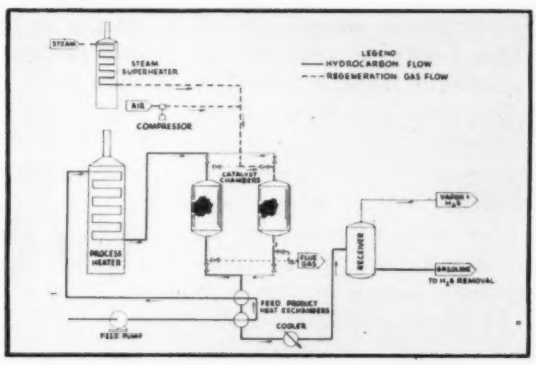
OF SOUR NATURAL GASOLINE

MEET today's market for high octane product. At a catalyst cost of only a fraction of a cent per barrel, a simple Perco Desulfurizer will remove 90 to 100 percent of the sulfur from sour natural gasoline. Desulfurized stocks gain up to 12.9 octane numbers at the 3 ml TEL level and maintain high lead response when blended with straight run or cracked gasolines.

The many installations prove the design, construction and operating features of Perco Catalytic Desulfurization. Operating cycles are long, eliminating the need for costly automatic control equipment. Yields are high with less than 0.5 percent volume loss customary between raw and finished storage.

***A SERVICE MARK**

Our Perco engineering staff will gladly study your sour natural gasoline situation. We will suggest a Perco Octane Insurance Program to improve the sales appeal of your product both now and in the future—by using the Perco Catalytic Desulfurization Process.



Perco Catalytic Desulfurization Process

Phillips 66

PHILLIPS PETROLEUM COMPANY

PERCO DIVISION • CHEMICAL PRODUCTS DEPARTMENT

BARTLESVILLE, OKLAHOMA

PROFIT WITH PERCO PROCESSES

Not Just "LOW-PRESSURE COMPRESSORS"

Two Worthington horizontal duplex opposed steam-driven RDV pumps (Type ODV) in the lubricating oil treating plant of a large refinery.

. . . but SPECIALIZED VACUUM PUMPS

Modern refinery practice demands the utmost efficiency in processing. And this efficiency can only be obtained with equipment that's *specifically designed for the job!* That's why, in refineries all over the world, WORTHINGTON is the top name in vacuum pumps.

These close clearance, high vacuum units are built with precision . . . Feather* Valves with hardened alloy seats and guards are the most efficient "breathers" made . . . extreme simplicity of construction gives unusual accessibility . . . top-grade materials insure greater ruggedness . . . conservative ratings give you abundant reserve power. No wonder, then, that in modern solvent extraction and solvent dewaxing plants WORTHINGTON vacuum pumps are the industry's first choice.

GET ALL THE FACTS

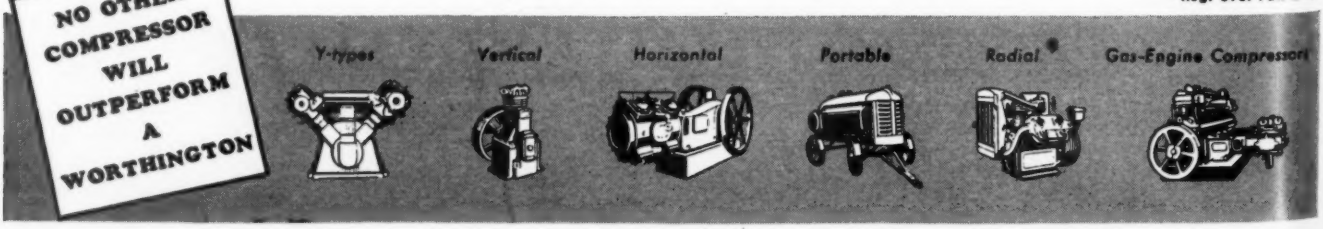
Worthington Horizontal Dry Vacuum Pumps are available in a variety of designs and drives permitting selection of the *right* unit to maintain the required vacuum at lowest operating cost. Bulletin L-710-B1B contains further facts proving *there's more worth in Worthington.* Write to *Worthington Pump and Machinery Corporation, Compressor Division, Buffalo, N. Y.*

WORTHINGTON

K.8.9

*Reg. U.S. Pat. Off.

NO OTHER COMPRESSOR WILL OUTPERFORM A WORTHINGTON



how to GET MORE WELDING from your PIPE WELDERS

The exceptional accuracy and uniformity of Midwest Welding Fittings enable the welder to spend more time in welding and less time in preparation. He does not have to struggle to line up fittings and pipe . . . all pipe can be cut in advance according to drawings . . . he need never compensate for inaccuracies. Time and money savings are substantial.

The dimensional accuracy and uniformity of Midwest Welding Elbows result from a unique method of manufacture. These elbows are first made slightly oversize . . . then reheated to forging temperature and brought to final size in *compression dies*. This assures true circular cross section, uniform wall thickness and accurate radius, included arc and tangents.

Midwest Welding Fittings save you money . . . there is a distributor near you . . . it will pay you to call him.

3718

MIDWEST PIPING & SUPPLY COMPANY, Inc.

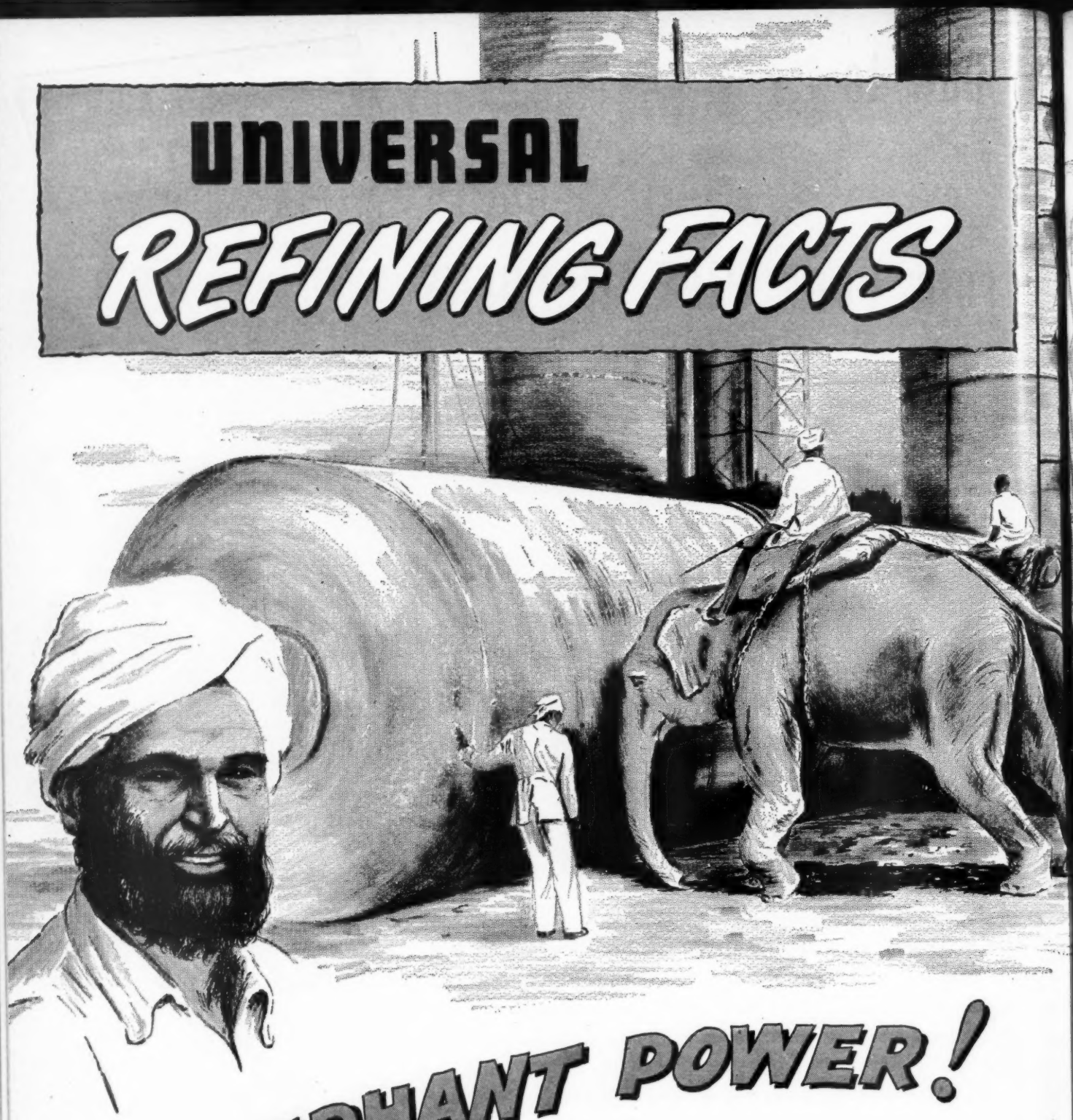
MAIN OFFICES: 1450 SOUTH SECOND ST., ST. LOUIS, MO.
PLANTS: ST. LOUIS, PASSAIC (N.J.) and LOS ANGELES

MIDWEST WELDING FITTINGS Improve Piping Designs and Reduce Costs

SALES OFFICES

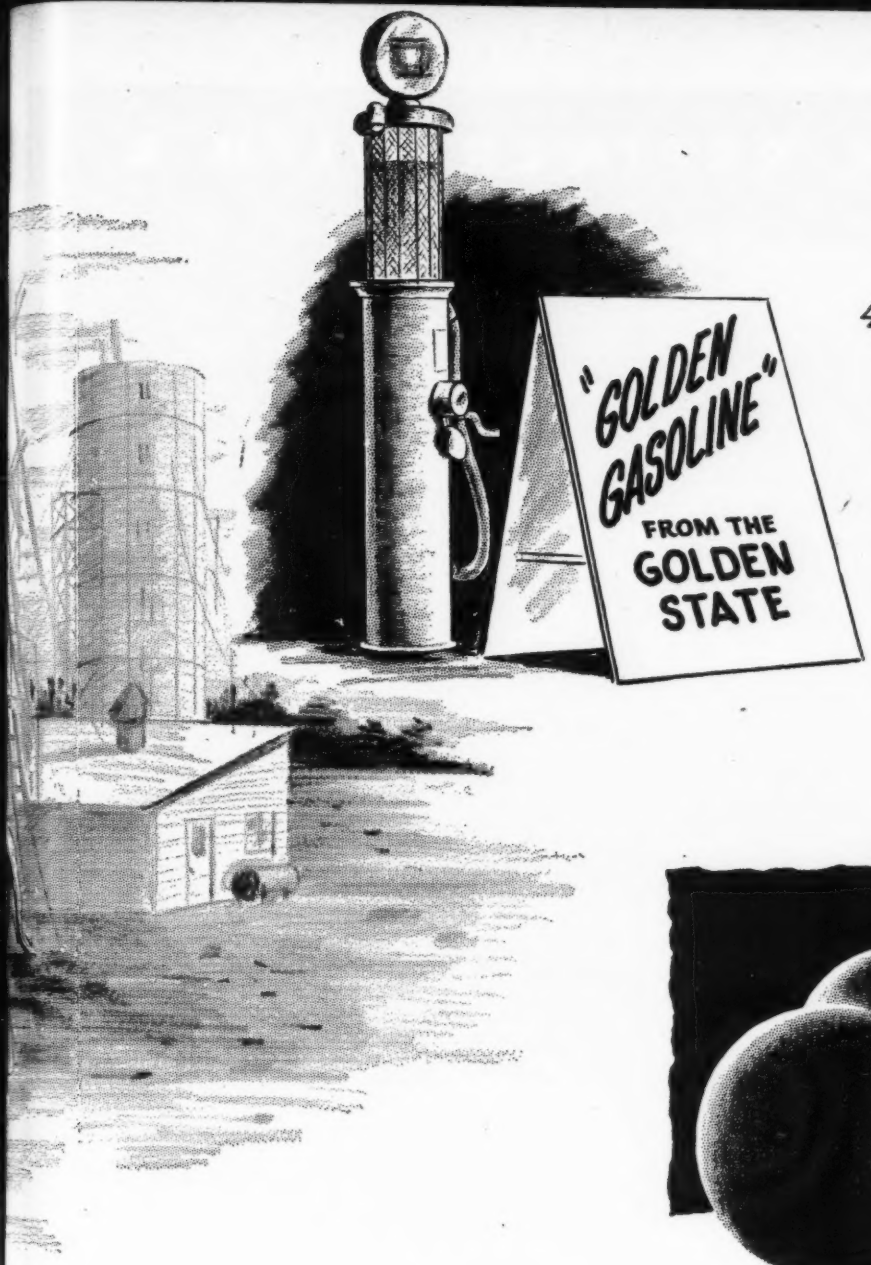
New York (7), 30 Church St. • Chicago (3), 79 West Monroe St. • Los Angeles (33), 520 Anderson St. • Houston (2), 229 Shell Bldg. • Tulsa (3), 533 Mayo Bldg. • South Boston (27), 426 First St. • Distributors in Principal Cities.

UNIVERSAL REFINING FACTS

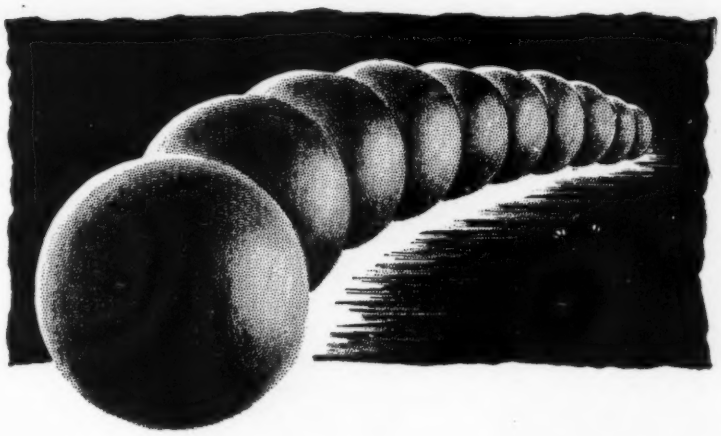


ELEPHANT POWER!

BACK IN THE 30's, CONSTRUCTION OF A THERMAL CRACKING UNIT AT DIGBOI, DEEP IN THE INTERIOR OF THE UPPER ASSAM REGION OF INDIA, CALLED FOR INGENUITY AND THE BEST USE OF FACILITIES AT HAND...ELEPHANT POWER IN THIS CASE. WHATEVER THE SITUATION, YOU WILL FIND UNIVERSAL SPECIALISTS MAKING EVERY EFFORT TO KEEP YOUR OPERATION MOVING ECONOMICALLY AND EFFICIENTLY.



THAT'S WHAT ONE EASTERN MARKETER TAGGED A TANKER LOAD OF CALIFORNIA CRACKED GASOLINE. HE THOUGHT IT WOULDN'T SELL ALONG SIDE OF STRAIGHT RUN WHITE GAS. IMAGINE HIS EMBARRASSMENT WHEN CUSTOMERS ASKED FOR MORE AND HIS NEXT TANKER ARRIVED WITH WATER WHITE STRAIGHT RUN. BUT "GOLDEN GAS" WAS PERFORMANCE PROVED. UNIVERSAL WAS AMONG THE FIRST TO URGE THE SALE OF CRACKED GASOLINE WITHOUT EXPENSIVE SULPHURIC ACID TREATMENT.



CUTTING CORNERS!

UNIVERSAL'S M-S (MICROSPHERICAL) CATALYST AVOIDS THE SHARP CORNERS AND IRREGULARITIES THAT CAUSE EROSION OF VESSELS AND PIPING AS WELL AS CATALYST LOSS THROUGH ATTRITION. ONLY 70 MICRONS (AVERAGE) IN DIAMETER, M-S LOOKS LIKE A FINE POWDER TO THE NAKED EYE...BALL BEARINGS THROUGH A MICROSCOPE.

OIL IS PROGRESS!

125 MILLION DOLLARS IS SPENT EACH YEAR BY U.S. OIL COMPANIES FOR RESEARCH... AND TEN THOUSAND PEOPLE ARE EMPLOYED BY THESE COMPANIES FOR THIS PURPOSE ALONE.

UNIVERSAL OIL PRODUCTS COMPANY

UOP General Offices: 310 S. MICHIGAN AVE., CHICAGO 4, ILLINOIS, U. S. A.

LABORATORIES: RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery

POROCEL converts flare gases to elemental sulfur

With more and more refineries running sour crudes, the problem of sulfide disposal becomes increasingly important. Ordinarily flared, these gases are now being utilized by converting them into premium grades of sulfur—hence into extra profits—through the use of Porocel.

Porocel catalyzes the reaction: $2H_2S + SO_2 \longrightarrow 3S + 2H_2O$. The element of catalyst cost is extremely favorable, since Porocel is low in first cost and displays a long life.

This is another example of Porocel serving the petroleum industry—another reason why it pays to know the *whole* Porocel "family" of activated bauxites. Included are:

Adsorbents—with high selectivity for removal of colors, odors, tastes, acids, fluorides, etc., from process liquids or gases.

Carriers—embodying ruggedness and adsorptive properties for use as catalyst supports.

Catalysts—high-surface-area materials for desulfurization* and reforming* systems, and for other catalytic duties.

Desiccants**—for drying petroleum gases and liquids, air, CO_2, etc.

May we introduce *you* to the Porocel that's "engineered" to your specific needs? Attapulgus Clay Company (Exclusive Sales Agent), Dept. D, 210 West Washington Square, Philadelphia 5, Pa.

* CYCLOCEL®
** DRIOCEL®

PORocel

ACTIVATED BAUXITES • SUPPORTED CATALYSTS • CATALYST CARRIERS • ADSORBENTS AND DESICCANTS

Controlled Quality

gives you steel heat code protection

ON EVERY FITTING AND FLANGE IN THE COMPLETE LADISH LINE

Pioneered by Ladish . . . and long recognized as its symbol of Controlled Quality . . . the Ladish steel heat code is visible evidence of added reliability resulting from metallurgical integrity. It protects you with certified laboratory reports always available giving specific test data as proof that all requirements of standard or special specifications are met or exceeded.

TO MARK PROGRESS

A COMPLETE LINE PRODUCED UNDER ONE ROOF
... ONE RESPONSIBILITY

LADISH CO.

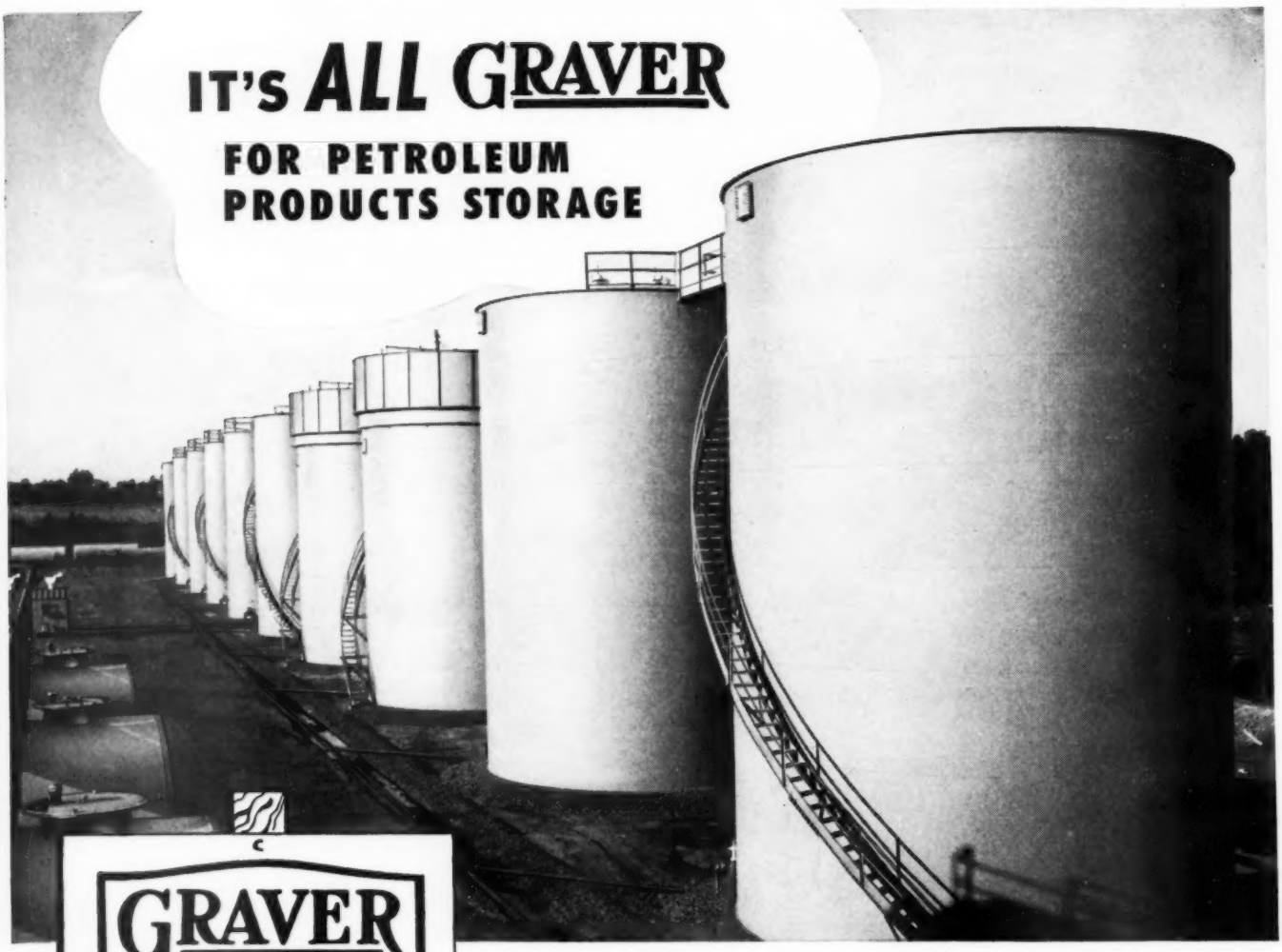
CUDAHY, WISCONSIN
MILWAUKEE SUBURB

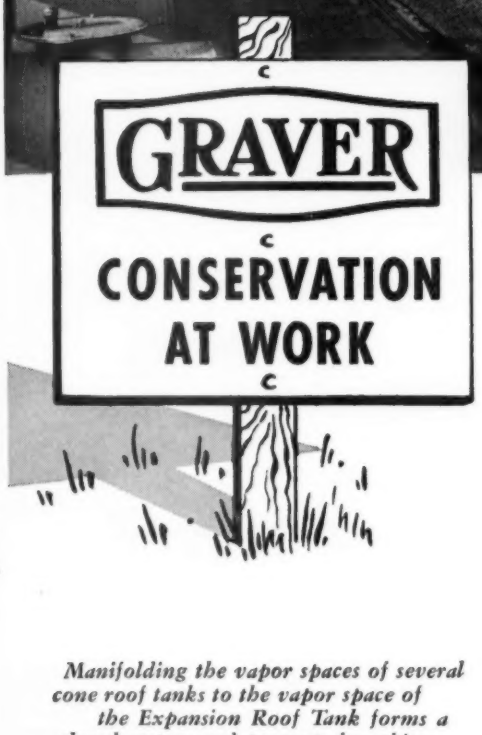
DISTRICT OFFICES: New York • Buffalo • Pittsburgh • Philadelphia • Cleveland
Chicago • St. Paul • St. Louis • Atlanta • Houston • Los Angeles

THE FITTINGS LINE INCLUDING CARBON, THAT IS COMPLETE IN TYPES, SIZE RANGES AND MATERIALS ALLOY AND STAINLESS STEELS, ALUMINUM, BRASS AND COPPER

IT'S *ALL* GRAVER

FOR PETROLEUM PRODUCTS STORAGE





Manifolding the vapor spaces of several cone roof tanks to the vapor space of the Expansion Roof Tank forms a closed system and prevents breathing and filling losses throughout the entire battery. The record of savings with this system is open for your inspection.

• Supplying dealer outlets over a 40-mile radius . . . this major oil company terminal is typical of Graver installations from coast to coast.

At this location are ten 33 x 48-foot tanks fabricated and erected by Graver — five cone roof tanks for kerosene and fuel oil and three cone roof tanks interconnected with two Expansion Roof Tanks for vapor saving gasoline storage.

With the emphasis on conservation it is imperative to recognize the value of the Graver Expansion Roof in preventing evaporation losses. It is likewise important to rely on Graver experience and facilities in the purchase of steel storage tanks for gasoline, kerosene, or fuel oil—whether it be field erected cone roof tanks or shop built bulk tanks. In any event . . . for any storage requirement . . . get in touch with Graver.

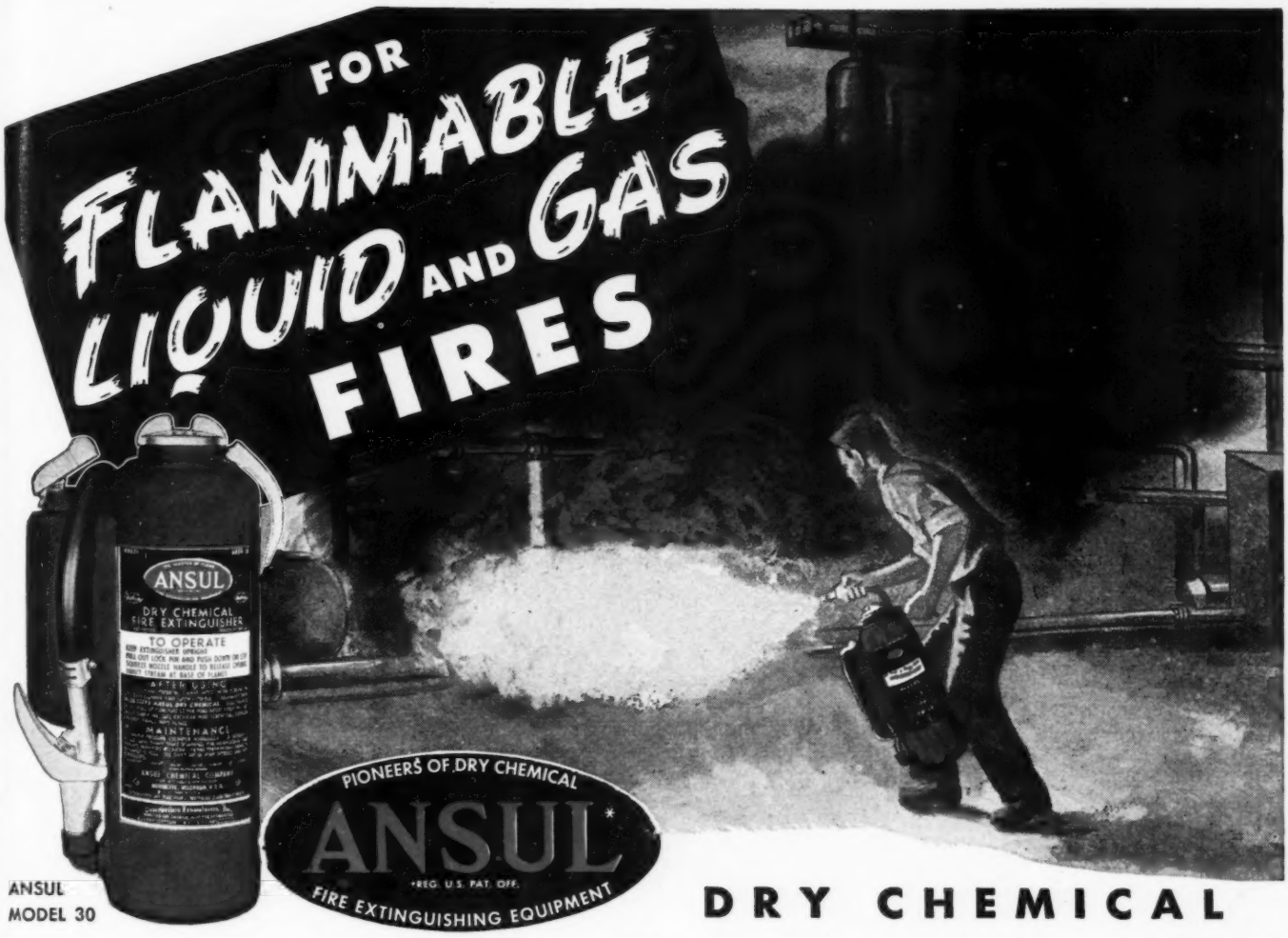
GRAVER

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA.



ANSUL MODEL 30

DRY CHEMICAL FIRE EXTINGUISHERS ARE YOUR *BEST* PROTECTION

...and most economical, too! Tests conducted by impartial, nationally recognized approval laboratories have proved the superiority of Ansul Dry Chemical Fire Extinguishers on ***Flammable Liquid Fires.***

Processing, handling, transferring and storing of all liquid and gaseous petroleum products involve fire hazards which demand the best in first-aid fire protection. For years the producing, refining and marketing divisions of major oil companies have been using Ansul Dry Chemical Fire Extinguishers as their first line of fire defense. There is a reason . . .

Get the facts. Send for your copy of File No. 430. You'll also receive our latest literature together with comparative rating charts for the various types of fire extinguishers.

- **Safe for use on electrical fires too! Even high voltages are not conducted by dry chemical stream.**
- **Can be recharged at scene of fire furnishing continuing protection.**
- **Annual recharging is not necessary. Low maintenance costs.**
- **Longer range stream of dry chemical is effective in winds and drafts.**
- **Ansul Dry Chemical is non-abrasive, non-corrosive, non-toxic.**
- **Listed and Approved by Underwriters Laboratories and Factory Mutual Laboratories.**

ANSUL CHEMICAL COMPANY

FIRE EXTINGUISHER DIVISION, MARINETTE, WISCONSIN

DISTRIBUTORS IN PRINCIPAL CITIES IN THE UNITED STATES, CANADA, AND OTHER COUNTRIES

Come to POWELL for ALL your Valves

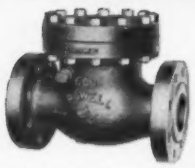


Fig. 6061—Class 600-pound Cast Steel Swing Check Valve.

There are obvious disadvantages in buying flow control equipment from several different sources. Then why get your bronze or iron valves from one place, your steel valves from another, and possibly corrosion-resisting valves from several others, when Powell *makes them all**?

This is an age of specialization; and whereas various manufacturers are emphasizing valves that meet certain flow control requirements, Powell specializes in making valves to meet *all* the demands of every branch of Industry. And there's only one standard of quality at Powell—to make the right valve to suit the service, and to make it the best.

Plants representing every branch of Industry have found that it pays to make Powell—and *only* Powell—responsible for the performance of all their flow control equipment. So why not come to Powell for all *your* valve requirements?

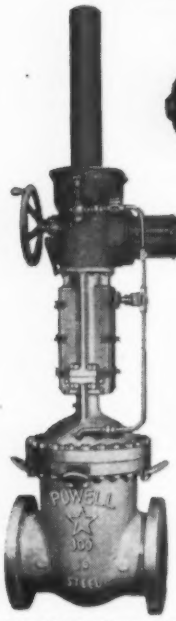


Fig. 3023—Class 300-pound Cast Alloy Steel Gate Valve with automatic steam sealing mechanism. Has explosion proof electric motor operator.

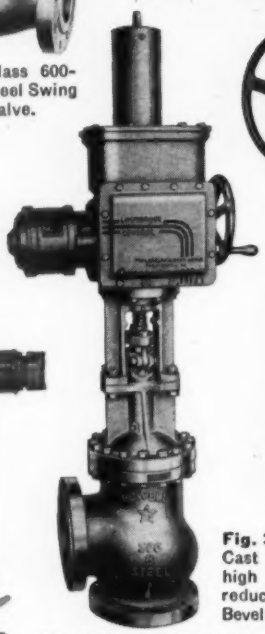


Fig. 3053 — Class 300-pound Cast Steel Angle Valve, equipped with top-mounted, fully enclosed, explosion-proof, electric motor operator for quick, positive opening and closing.

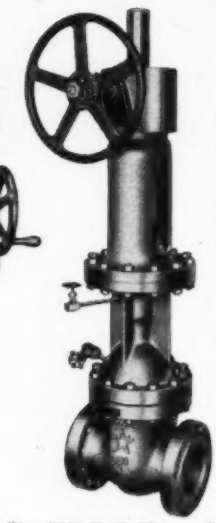


Fig. 3003 S. S. Mod.—Class 300-pound Cast Alloy Steel Gate Valve for ultra-high temperatures. Has cooling fins to reduce temperature in the stuffing box. Bevel gear operated.

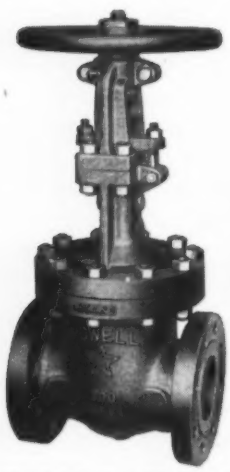


Fig. 3003—Class 300-pound Cast Steel O. S. & Y. Gate Valve.

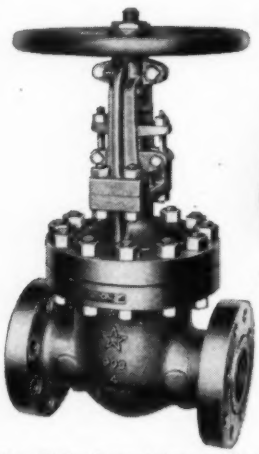


Fig. 9003—Class 900-pound Cast Steel O.S.& Y. Gate Valve.

Fig. 1793—Large 125-pound Iron Body Bronze Mounted O.S.& Y. Gate Valve.

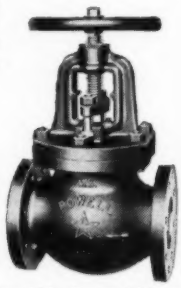


Fig. 241—Large 125-pound Iron Body Bronze Mounted O. S. & Y. Globe Valve.

Fig. 8150—Bronze L. P. G. Globe Valve with screwed ends, union bonnet and special composition disc.

Fig. 1708 — 200-pound Bronze Globe Valve with renewable stainless steel seat and regrindable, renewable "Powellium" nickel-bronze disc. ➔

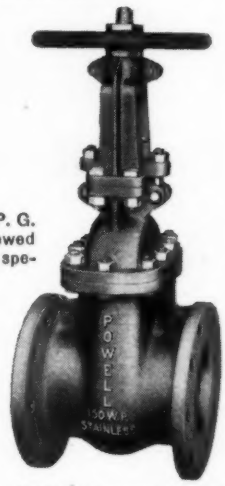


Fig. 2453-G—Large 150-pound Stainless Steel O. S. & Y. Gate Valve. Sizes 5" to 30".

* Powell Valves are made in Bronze, Iron, Steel and a wide selection of Corrosion-Resistant metals and alloys. Valves of every type—Globe, Angle, Gate, Check, Non-return and Flush Bottom Tank Valves—are included in the Complete Powell Line.

Fig. 1314-A — Class 1500-pound Steel Integral Bonnet "Y" Valve. Also made in Globe and Angle patterns.

Fig. 375 — 200-pound Bronze Gate Valve with renewable "Powellium" nickel-bronze disc.

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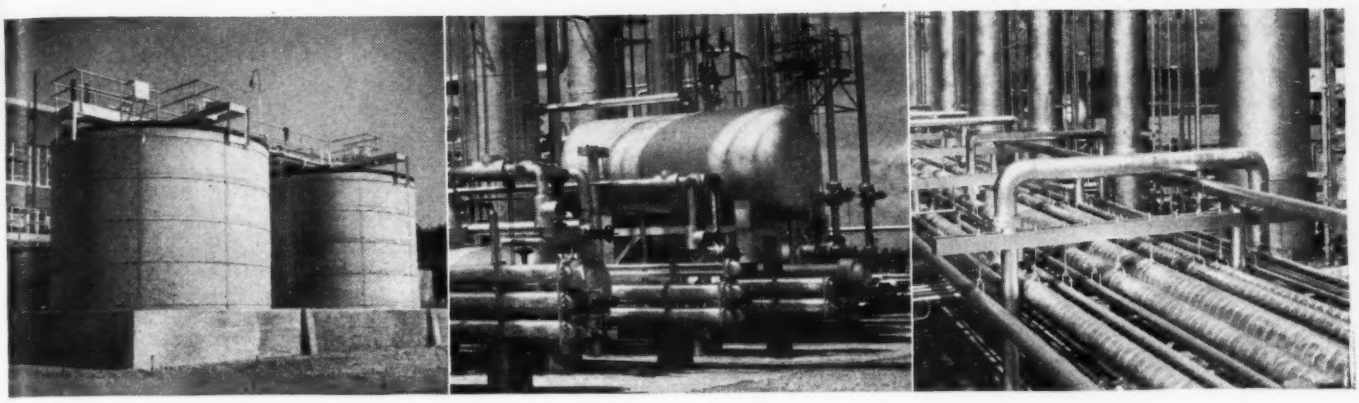

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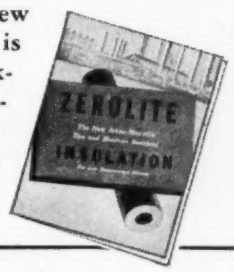

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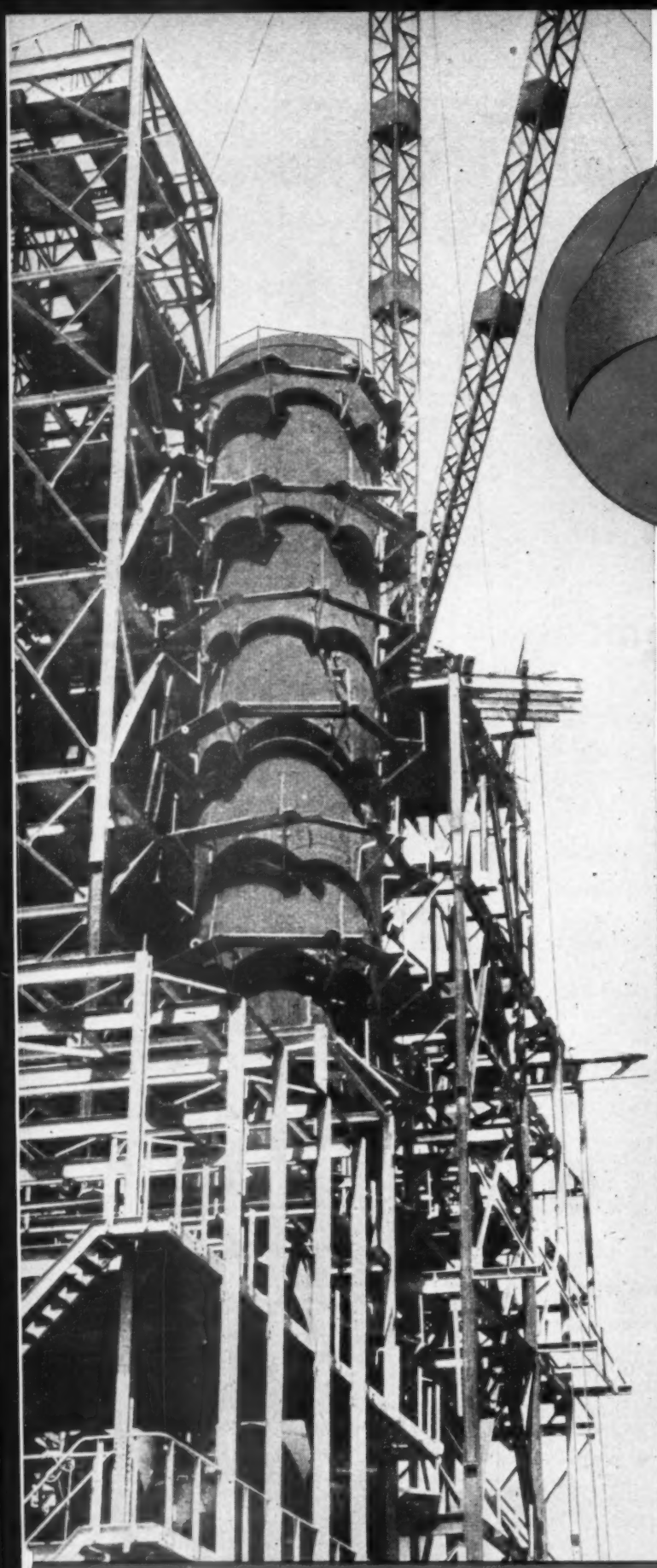

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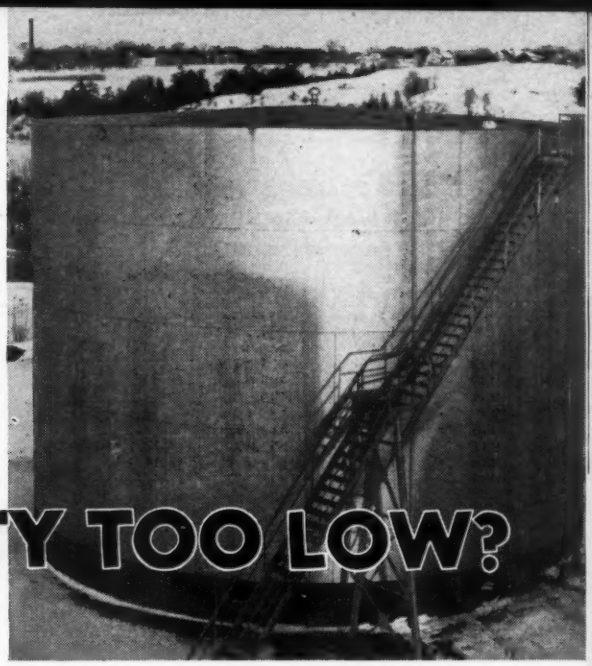

IS TANKAGE CAPACITY TOO LOW?

THE matter of the industry's present running product inventories, in relation to demand factors, was among the topics considered at the recent annual meeting in Chicago of the American Petroleum Institute. While it was a coincidence only that this subject was brought up in three papers, these public references indicate that increasing attention is being given among the oil companies to this subject.

One speaker suggested that refinery operations might be carried on more efficiently if storage capacity were increased, to provide for the plants carrying a larger proportion of their output in tankage in period of low seasonal consumption to meet later demands of the peak consuming period.

The shortage of present product tankage would seriously hamper the industry's operations in a national emergency, another speaker stated. Still another, in a brief reference, called attention to the fact that crude and product storage is now about the same total as in 1931, while crude production has more than doubled.

Seasonal Demands Are Spreading

"Wide swings in the normal level of demands at different times of the year," said Courtney C. Brown, Standard Oil Co. (New Jersey), "have given rise to a whole new set of operating problems—and particularly to a requirement for more storage capacity and the practice of using it." (1)

The evening out over the year of the gasoline market has been one factor in the reversal between the levels of winter and summer demands, he said, but the most dominant influence in the changed relationship has been the growth in the light burning oil market. "Instead of being a peak load industry in the summer, as it was in the 1920's" he said, "oil is now a peak load industry in the winter, and the peaks are apparently going higher and higher with the passage of time. The winter of 1948-49, which was an unusually warm one, stands as an exception to these increasing spreads, but it is not safe to count on that being repeated. The demand for burning oil changes in a volatile and unpredictable manner with changes in the weather."

The normal winter demands of the industry have now been pushed to something like 500,000 b/d ahead of the preceding summer, Mr. Brown said. Winter demands in the three postwar winters ended with March, 1949, averaged 543,000 b/d more than their preceding summers. By way of contrast, demands of the three winters ended with March, 1937, averaged only 83,000 b/d more than their preceding summers. This widening seasonal swing, he said, has created a long-range operating problem which affects all refiners.

There are three practical ways for the oil industry to adjust itself to the increased seasonals, it was pointed out, in practice the three being used in combination. Said Mr. Brown on this point:

"First, if total supply capacity is sufficiently higher than the average annual requirements, activity can be expanded during the period of seasonal peak. This method is available at the present time through the use of shut-in crude production, and of spare refinery capacity and tankers. But this method of making additional heating oil available during the seasonal peak can be practically used only to the extent that it does not compel excessive production of other products, including gasoline, for which there would be an inadequate demand in an off-season period. Moreover, it is an expensive method.

"A second way of meeting the sea-

"Fuels of the Future" Reprints Are Available

So much valuable information and statistical data blueprinting the petroleum industry's future supply and demand requirements is contained in the papers presented at the "Fuels of the Future" session at the recent API meeting that PETROLEUM PROCESSING is making them available in reprint form. The reprint contains the following three papers, complete with all text and illustrations:

"Liquid Fuel Supplies and National Security," by Walter G. Whitman, Massachusetts Institute of Technology.

"Fuels—Their Present and Future Utilization," by W. M. Holaday and associates, Socony-Vacuum Laboratories.

"Effect on Refinery Operation of Increasing Seasonals in Petroleum Product Demand," by Courtney C. Brown, Standard Oil Co. (New Jersey).

Copies of the reprint (32 pages, 8¼ x 11¼ in., heavy paper cover) are available for 50 cents each, postpaid. (Ohio purchasers please add 3% state sales tax.) Address orders, with remittances, to:

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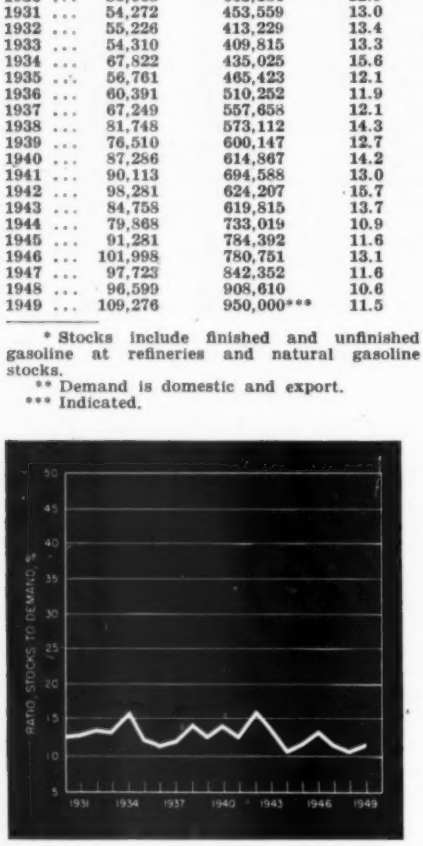
TABLE 1—Ratio of Motor Fuel Stocks to Demand

(Thousands of Bbls.)

Year	Stocks, Jan. 1*	Demand,** Inc. Exports	Ratio, Stocks To Demand, %
1930 ...	56,068	463,184	12.9
1931 ...	54,272	453,559	13.0
1932 ...	55,226	413,229	13.4
1933 ...	54,310	409,815	13.3
1934 ...	67,822	435,025	15.6
1935 ...	56,761	465,423	12.1
1936 ...	60,391	510,252	11.9
1937 ...	67,249	557,658	12.1
1938 ...	81,748	573,112	14.3
1939 ...	76,510	600,147	12.7
1940 ...	87,286	614,867	14.2
1941 ...	90,113	694,588	13.0
1942 ...	98,281	624,207	15.7
1943 ...	84,758	619,815	13.7
1944 ...	79,868	733,019	10.9
1945 ...	91,281	784,392	11.6
1946 ...	101,998	780,751	13.1
1947 ...	97,723	842,352	11.6
1948 ...	96,599	908,610	10.6
1949 ...	109,276	950,000***	11.5

* Stocks include finished and unfinished gasoline at refineries and natural gasoline stocks.
** Demand is domestic and export.
*** Indicated.



sonal peak requirements for burning oils is to shift refinery yields. Refinery equipment can be adjusted, and has been adjusted in the past, to help accommodate the seasonal changes in the pattern of product demands. But there are limits beyond which the refineries cannot go without incurring prohibitive costs. Flexibility is limited by refinery equipment and processes but, within the limits of efficient operation, yields have been and will continue to be adjusted to some extent with the seasons. These shifts in yield are encouraged, of course, by changes in the relative realizations of the several products at the refinery during the different seasons.

"A third way to adjust to changing seasonal requirements is by adding to inventories in the slack season the stocks that would be delivered in the peak season. Hypothetically, if it were possible to guess precisely the level of future requirements, it would be possible to achieve a year-round uniformity of crude production, refinery runs and yields. This could be done by letting all the come-and-go of seasonal variation fall on inventory accumulation and inventory drafts.

"Of course, it is not possible to forecast precisely what the future holds, and there is a risk element in any inventory operation. On the other hand, it is not desirable, nor is it good and prudent business judgment, to rely entirely on unused facilities, together with the flexibility of refinery yields, to meet the vicissitudes of weather, and the successively higher peak seasonal requirements of the burning oil market. That might have been all right when the seasonal peaks were less pronounced than they are at present. But the record shows that these peaks have been getting higher with the passage of time, which means that the risks of failing to cope with them on a sound operating basis become greater. Those risks involve the possibility of interruption to the normally smooth flow of supplies, as well as the risks of incurring unnecessary operating and capital costs."

The amount by which domestic demands of the past three winters for the whole country have exceeded demands of the preceding summers—543,000 b/d—is roughly about 10% of our annual average requirements, Mr. Brown pointed out. To provide 10% more capacity for winter than for summer demands means than 5% of total annual capacity must exist as a reserve.

"Such excess capacity would amount to something like 250,000 to 300,000 b/d at the present level of demands" he said. "A capital cost figure of $4500 per bbl. per day for such capacity in all three functions—producing, refining and transportation—may be a reasonably acceptable figure. On this basis this excess capacity would represent an investment well in excess of $1,000,000,000.

Tankage Would Cost 90% Less

"To provide above-normal storage to be filled during the season of lower consumption—say 300,000 b/d for 6 months, equal to about 55,000,000 bbls.—the investment involved would come to less than $100,000,000, assuming a capital cost of $1.50 per bbl. for tankage. A reasonable degree of interchangeability of white product storage would mean that the capital cost would be still smaller. That's less than 10% of the cost of doing the job with other kinds of capacity, which is more than an adequate margin to offset added costs and greater risks of carrying large average inventories.

"These figures are clearly approximations. They are adequate, however, to demonstrate the very large capital savings that could be made if refiners should gradually adopt the operating practice of letting the changing seasonal requirements fall more on storage, and less on changing volumes of currently produced supplies.

"The time to begin preparing for that is now. Tankage built this winter would be available to be filled next summer. Unless storage space is then available, and unless the industry has the courage and foresight to fill it, then still another seasonal cycle of falling and rising supply operations must be anticipated.

"The present practice of adjusting current supplies to coincide with changing seasonal demands cannot help but result in shut-in crude, idle refinery and pipeline capacity, and tied-up tankers for a part of the year every year. And that means idle capacity of the most expensive kind."

National Security Involved

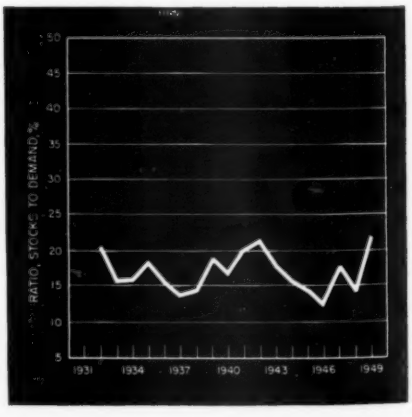
The industry's present practice as regards product inventories was also commented on at the Chicago API meeting, by Walter G. Whitman, head of the Department of Chemical Engineering, Massachusetts Institute of Technology.[2] Speaking before the session on "Fuels of the Future" he outlined an industry program to insure adequate supplies of liquid fuels for national security. A part of his preparedness program calls for having available, before an emergency, around 150,000,000 bbls. of empty

TABLE 2—Ratio of Distillate Fuel Stocks to Demand

(Kerosine Included)
(Thousands of Bbls.)

Year	Stocks, Jan. 1	Demand, Inc. Exports	Ratio, Stocks To Demand, %
1930 ...	.....	.....	...
1931 ...	.....	.....	...
1932 ...	23,858	118,148	20.2
1933 ...	19,251	123,660	15.6
1934 ...	22,873	143,345	15.9
1935 ...	28,355	156,573	18.1
1936 ...	27,845	181,569	15.4
1937 ...	28,446	210,828	13.5
1938 ...	29,649	210,954	14.0
1939 ...	44,023	235,737	18.6
1940 ...	41,294	252,141	16.4
1941 ...	52,423	262,439	20.0
1942 ...	59,529	279,579	21.2
1943 ...	55,004	316,417	17.4
1944 ...	51,087	329,511	15.5
1945 ...	49,483	341,333	14.5
1946 ...	46,199	370,106	12.2
1947 ...	76,701	437,901	17.5
1948 ...	68,803	477,556	14.4
1949 ...	99,963*	454,000**	22.0

* Old basis of reporting.
** Indicated.



tankage to receive the first products for stockpiling in the event of war or other emergency and the accompanying prompt rationing of civilian consumption. On the matter of inventories Professor Whitman said:

"The oil industry seems to be trying to get along with too little product storage capacity for its regular business. The shortage of present industry tankage is indicated by comparing the low point on total stocks of crude, refined products, and natural gasoline with the high point of such stocks since December, 1946. Within this period there has been both a shortage threat, which aroused the industry to maximum efforts to avert it, and an oversupply condition, which resulted in reduced production and refinery runs.

"The low point on stocks was in March, 1947, when the Bureau of Mines report showed 481,000,000 bbls.; the high was this past summer, with 636,000,000 bbls. The difference between high and low, representing the effective range of industry storage, is only 155,000,000 bbls., or less than a month's supply.

"A shortage of industry tankage would seriously hamper operations in an emergency. But this is not a case for government aid. It appears that the industry needs, and probably will provide, considerably more tankage for its regular operations."

In a general address before the API, Senator Robert S. Kerr, of Oklahoma, described the growth of oil industry operations in terms of crude production and inventories of crude and refined products.(3) "In 1931, 851,000,000 bbls. of oil were produced, at an average price of 65c", he said, "and at the year's end total crude and refined storage was 632,623,000 bbls. In 1933, 905,000,000 bbls. were produced at an average price of 67c and, at the year's end, total crude and refined storage was 603,207,000 bbls. In 1948, 2,016,282,000 bbls. were produced and at the year's end total crude and refined storage was only 607,483,000 bbls."

A study of the trend in relationship of inventories of crude and refined products to demand was made by PETROLEUM PROCESSING, the results being shown in Tables 1, 2, 3 and 4. Stocks on hand Jan. 1 of each year, starting with 1930, are compared with the total of domestic and export demand for that year. Stocks of refinable crude oil and the principal products, motor fuel, distillate fuels (including kerosine), and residual fuels in total were less Jan. 1, 1949, than in 1932, while in the same period the demand for these products had more than doubled. This is due to the fact the industry today finds it possible to carry far less inventories in crude oil than in the early 30's. The volume of residual fuels in storage Jan. 1 also was around 35% less than in 1932, while consumption of this product has doubled in the 1930-49 period.

Ratio for Light Products Steady

With motor fuel and distillate fuel oils, however, the relationship between stocks and demand has been fairly consistent through the period. The oil companies carried about 13% of motor fuel consumption in storage at the start of 1930 and the 1949 percentage ratio is 11.5%. For the distillate fuels, including kerosine, the oil companies carried slightly better than 20% of 1932 demand in storage at the start of the year. That year was the first in which the Bureau of Mines segregated light from heavy fuel stocks and reported them separately. The ratio of storage to demand dropped to a little over 12% in 1946 and, due largely to the unseasonably warm preceding winter, stocks of distillate fuels on Jan. 1 of this year were 22% of indicated 1949 demand. Thus, it is indicated that the practice of the oil companies has been to add to their storage facilities for light oils in approximately the same proportion as demand for these products has increased over the years.

The reason for the large decrease in the actual volume of crude carried in tankage at present as compared with 1930 is to be found in the greatly increased extent to which proration, either voluntary or by state agencies, is now in effect. Crude oil is produced in most of the producing states in close line with demand, while in the early 1930's fields were still being produced and the oil run to storage if demand was not sufficient. The great increase in the number of pipelines, tankers, barges and other transportation facilities also provides for moving oil from producing fields to refineries about as needed.

The drop over the 1930-49 period in stocks of residual fuels the oil companies carry is due in part at least to the growing practice to separate out from them stocks which can be processed into the more valuable lighter products. In California until this year it was the practice to classify some of the heavy crudes produced there with their residual fuel oils.

TABLE 3—Ratio of Residual Fuel Stocks to Demand

(Thousands of Bbls.)

Year	Stocks, Jan. 1	Demand, Inc. Exports	Ratio, Stocks To Demand, %
1930 ...	.....	.....	...
1931 ...	.....	.....	...
1932 ...	116,867	254,268	46.2
1933 ...	116,476	260,735	44.9
1934 ...	106,689	279,646	38.4
1935 ...	88,440	293,394	30.2
1936 ...	84,054	322,319	26.0
1937 ...	84,236	340,818	24.8
1938 ...	96,012	307,791	31.1
1939 ...	118,438	344,110	34.5
1940 ...	105,620	357,696	29.5
1941 ...	99,932	399,263	25.1
1942 ...	93,138	417,850	22.3
1943 ...	72,648	484,478	14.9
1944 ...	55,756	525,721	10.6
1945 ...	56,490	536,643	10.6
1946 ...	41,654	488,010	8.6
1947 ...	52,797	529,117	9.9
1948 ...	52,816	513,298	10.2
1949 ...	76,942*	501,000**	15.°

* Old basis of reporting.
** Indicated.

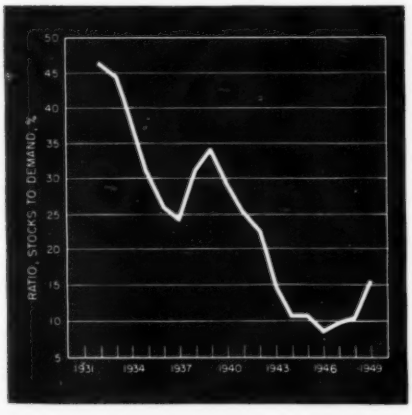
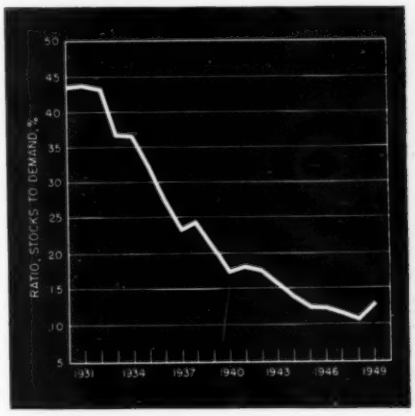


TABLE 4—Ratio of Crude Oil Stocks to Demand

(Refinable Crude)
(Thousands of Bbls.)

Year	Stocks, Jan. 1	Demand, Inc. Exports	Ratio, Stocks To Demand, %
1930 ...	428,445	979,776	43.8
1931 ...	411,882	939,294	43.9
1932 ...	370,194	860,320	43.1
1933 ...	339,875	922,112	36.9
1934 ...	354,223	960,592	36.8
1935 ...	337,254	1,051,207	32.1
1936 ...	314,855	1,158,290	27.2
1937 ...	288,579	1,250,674	23.1
1938 ...	305,833	1,271,642	24.1
1939 ...	274,165	1,332,244	20.6
1940 ...	239,978	1,371,146	17.5
1941 ...	264,709	1,470,044	18.0
1942 ...	247,499	1,410,808	17.6
1943 ...	234,889	1,510,329	15.6
1944 ...	242,132	1,743,979	13.9
1945 ...	220,663	1,789,894	12.3
1946 ...	218,763	1,814,295	12.1
1947 ...	224,473	1,953,183	11.5
1948 ...	224,929	2,119,775	10.6
1949 ...	246,199	1,973,200	12.5



References

(The following papers were all presented at the 29th Annual Meeting, American Petroleum Institute, Chicago, Nov. 7-10, 1949.)

(1) Brown, Courtney C., "Effect on Refinery Operations of Increasing Seasonals in Petroleum Product Demand," *National Petroleum News*, 41, No. 46, pg. 26 (Nov. 16, 1949).

(2) Whitman, Walter G., "Liquid Fuel Supplies and National Security," PETROLEUM PROCESSING, 4, No. 11, pg. 1222 (Nov., 1949).

(3) Kerr, Hon. Robert S., "America Unlimited."

DESIGNED TO HANDLE SOUR CRUDE

Processes, Equipment, Materials in New Refinery Of Continental at Billings, Mont., Have Been Planned To Give Efficient Service on High-Sulfur Crudes

By D. P. THORNTON, Jr.
Southwestern Editor

DESIGN features of the new $9,500,000 refinery of Continental Oil Co., at Billings, Mont., are keyed to the production of quality products from low gravity, sour crudes, with a minimum output of heavy residual fuels. Dedicated Oct. 8, the 7500 b/d plant, built by Jones & Laughlin Supply Co., is now fully on stream after satisfactorily passing performance tests.

The most modern designs of processing techniques are utilized in the plant and alloy-clad steels are provided where necessary to resist sulfur corrosion. Propane deasphalting is relied upon to prepare heavy cracking stock and reduce residual fuel production. Fluid catalytic cracking produces quality motor fuel, increases plant flexibility by permitting further reduction of burning oil production at will and, in a separate reactor, catalytically desulfurizes straight-run gasoline and distillate fuels. Refinery gases are polymerized to gasoline, used for blending and the balance above plant fuel requirements disposed of as liquefied petroleum gases.

The Billings refinery is in effect a single, integrated unit, having interlocking control instrumentation to provide the necessary operating coordination since no intermediate tankage has been provided. Crude and product storage capacity is 700,000 bbls. Loading racks and related blending facilities, boiler plant, offices, laboratory and locker room combined in a modernistic buiding, and warehousing are well designed and of ample size. The plant site is a 118-acre tract on the city outskirts, and provides ample room for future expansion. Approximately 150 men will be employed, representing an annual payroll of $500,000.

The new refinery is designed to give a yield of approximately 58% as 10-lb. Reid vapor pressure gasoline having unleaded octane ratings of 73.5 Motor and 80 Research. Middle distillate yields are estimated at 15%; fuel oil and asphalt, 22%, and LPG—propane and butane—3.5%. A schematic flowsheet for the operation appeared in PETROLEUM PROCESSING for April, 1949, p. 410.

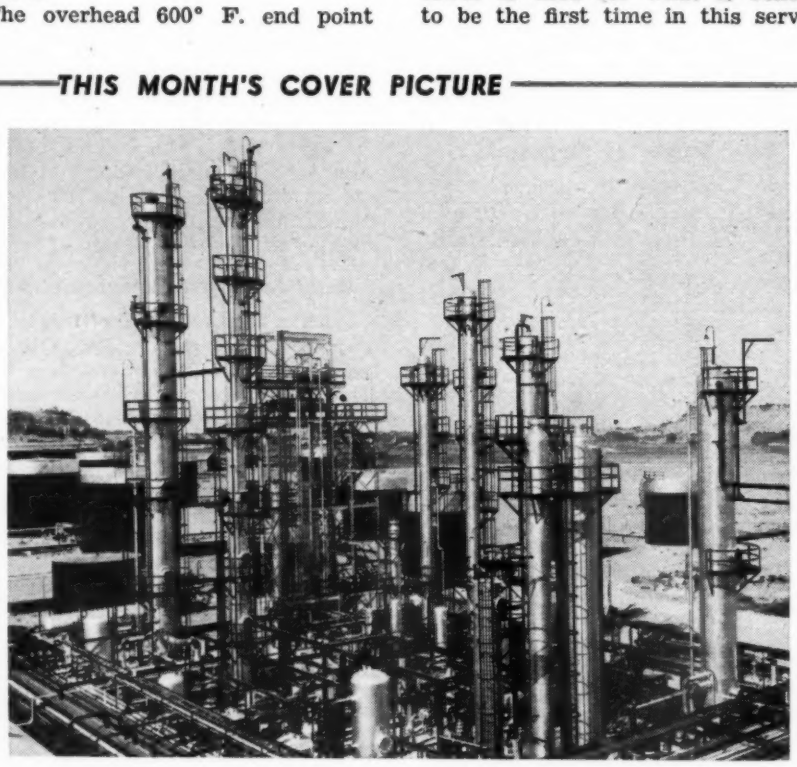
The crude unit, consisting of a 7-ft. diameter distillation tower, containing 16 trays and a conventional J. & L. tube still heater, splits into three streams an approximately 28.1° API gravity blend of 60% Elk Basin (29.6° API) and 40% light Frannie (26.5° API) crudes having a sulfur content of 2.2 wt.%. Crude enters the unit through bottoms-to-feed and circulation reflux-to-crude exchangers providing a preheat to 470° F. and is charged to the fractionator at about 750° F. The products are given in Table 1.

The overhead 600° F. end point product contains both straight-run gasoline and light fuels. It is charged directly to the desulfurization reactor of the Fluid unit. The virgin gas oil side cut provides part of the catalytic cracking charge and also may be diverted to distillate fuel. The total reduced crude bottoms product is charged to propane deasphalting.

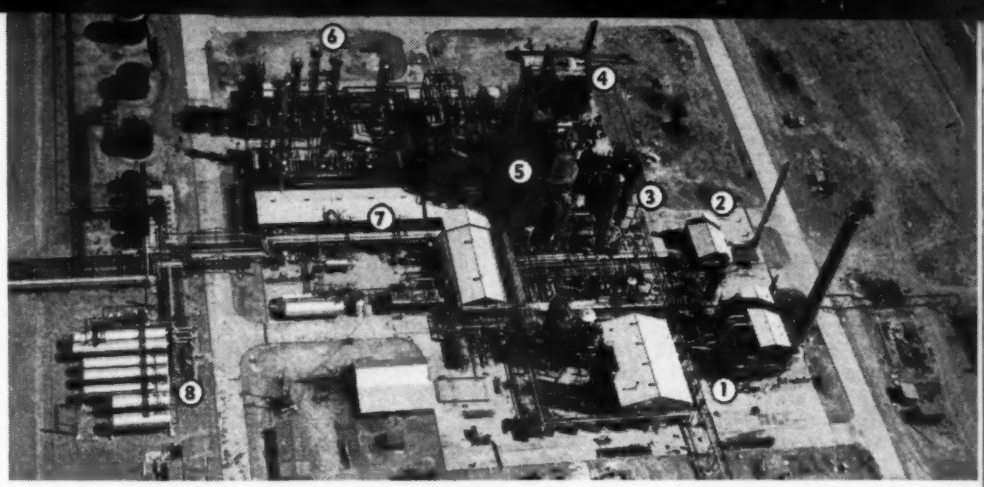
Propane Deasphalting

Propane deasphalting of reduced crude is used in lieu of a vacuum still to prepare charging stock for catalytic cracking. The Continental unit is unique in that a vertical extraction tower is used for what is believed to be the first time in this service.

THIS MONTH'S COVER PICTURE



The vapor recovery area of Continental's new 7500 b/d Billings refinery is an intricate maze of towers and pipe. Major items visible include, left to right, de-ethanizer-absorber and debutanizer, gas recovery section; twin polymerization reactors in steel structure, with small vessel at right poly feed stream water scrubber; de-ethanizer, depropanizer and (background) debutanizer of poly unit, and right, amine unit regenerator. The three towers in center foreground are, left to right, caustic scrubber, and vapor and liquid amine treaters for H_2S removal



Aerial view of Continental's $9.5 million Billings refinery. Visible are: (1) Boiler plant, control and water treating house; (2) crude heater; (3) crude distillation; (4) twin reactor cracking unit; (5) propane deasphalting; (6) light ends treating, recovery and poly units; (7) main control room, compressor house and pump room; (8) LPG storage

Solvent deasphalting of course is not a new process, although it still is uncommon in this application. Engineers of Continental and Jones & Laughlin collaborated in the tower design.

The unit is engineered to handle 2870 b/sd of reduced crude, from which it yields a net overhead product of 1985 bbls. of 21° API gas oil and 885 bbls. of −3.4° API asphalt bottoms. The crude tower bottoms stream is cooled by exchange with crude to a charge temperature of 160° F., entering the deasphalting tower without prior admixture with propane. Ratio of propane solvent to feed is 6:1, representing a propane circulation of about 17,000 b/d.

The vertical extraction tower is 9 ft., 7.5 in. in diameter by 54 ft. high, designed to withstand 636 psi. at 260° F. It has 16 perforated trays, an accumulator section in the bottom, and 10 steam heating coils uniformly spaced in the upper two-thirds. Three feed entrance nozzles are located in the upper half of the tower, although only one will be used normally. Propane is injected at three points in the lower half of the tower, flowing upward and countercurrent to the asphalt.

The solubility of asphalt in propane, hence the extent of extraction, varies with temperature, which therefore must be carefully controlled. Tower top temperature is measured by a recording temperature controller regulating steam flow to the heating coils previously mentioned. The top operating temperature will be 180° F. maximum. The bottom temperature will be approximately 110° F., controlled by temperature of solvent propane feed. A pressure controller on the overhead product line maintains the normal operating pressure of 500 psi.

The bulk of the propane leaves the tower with the deasphalted overhead oil and is recovered in three stages; namely, first stage evaporator, second stage flash, and deasphalted oil stripper, operating, respectively, at 305, 205 and 2 psig. The bottoms stream from the tower consists of approximately half and half propane and asphalt. This is heated to 600° F. in a vertical upshot Petro-Chem heater and flashed at 205 psig. Remaining propane is removed with steam in an asphalt stripper operating at 2 psig. Propane from the two low-pressure strippers is recompressed for delivery to the solvent condensers. The residual asphalt is blended to heavy fuel oil with cycle gas oil from the cracking unit.

While it is desirable and the unit is operated to keep solvent propane losses at a minimum by adequate flashing and stripping, there is not much chance for propane to "get away" except through equipment leaks or in the asphalt. Most of any unrecovered propane leaving the deasphalting step will proceed through catalytic cracking and ultimately be caught in the vapor recovery system, which compares favorably with modern natural gasoline plants in that it is designed for 85% C_3 recovery.

Fluid Cracking Unit

The catalytic cracking unit proper is designed to process 3770 b/d of 23 to 25.5° API virgin gas oil. However, it differs from the conventional installation in that a second reactor is provided to desulfurize the combined straight-run gasoline and light distillate stream. Consequently the regenerator is somewhat larger than required only for cracking service. The catalyst is microspherical silica-alumina, 175 tons constituting initial charge.

The catalytic cracking reactor is 15 ft. in diameter and contains an internal stripper for spent catalyst leaving the vessel. Single-stage cyclone separators are installed in the top of the reactor. Catalyst circulation rate will be 525 tons per hour. The reactor is installed high in the structure to provide gravity return of spent catalyst to the regenerator.

The regenerator is 23 ft. in diameter and 50 ft. high, handling catalyst at the rate of about 550 tons an hour. Two-stage cyclone separators have been installed to reduce catalyst losses in the flue gas and a waste-heat boiler generating 175-lb. steam is provided to recover heat.

Regeneration air is provided by a Carrier centrifugal compressor running at 4500 rpm. and capable of supplying 25,000 cfm at 39 psia. with 13 psia. section pressure. It is said to be the first and largest of its design for refinery service. The Worthington steam turbine which drives it consumes 2600 Hp. of 600 psi. steam, exhausting to 27 in. of Hg vacuum.

The catalytic cracking reactor is intended to operate at 79% convertion when recycling approximately 5000 b/d of cycle stock. Virgin feed composition and yields expected are given in Table 2.

Vapors from the reactor are charged to the main fractionator, where gasoline and lighter are taken as an overhead product to a receiver separating liquid and vapor. The two materials go to twin diethanolamine Girbotol treaters for hydrogen sulfide removal. Heavy naphtha and light cycle gas oil are produced from strippers as column side-draw products. Heavy cycle gas oil bottoms are circulated for reboiler duty in the gas concentration plant and for steam generation. Some of it is diverted for blending with asphalt to No. 6 fuel, another portion as heavy fuel and the balance returned to catalytic cracking.

The catalytic desulfurization reactor will be maintained at 700° F. substantially reducing the sulfur content of the straight-run gasoline and light heating oils. Catalyst circulation is about 26 tons hourly. Following this operation the vapors, at 700° F., are charged to the rerun unit, the principal equipment of which is a 32-plate fractionating column preparing six separate streams, all but two being stripped. The products and their approximate boiling ranges are

TABLE 1—Crude Unit Product Streams

Stream	Volume, b/sd	% of Crude	Gravity, °API
600° F. EP overhead ..	3,551	47	...
Gas oil	1,133	15	24.8
Reduced crude	2,871	38	12.5

TABLE 2—Catalytic Cracking Charge and Expected Yields

Component	Cracker Feed, b/sd
Deasphalted gas oil	1,985
Atmospheric gas oil	1,130
Heavy distillates	655
TOTAL	3,770

Product	Cracker Yields Liquid Vol.-%
Debutanized 400° F. EP Gasoline	56
Cycle gas oil	21
Butane-butylenes	15
Propane-propylene	11
Ethane and lighter	4*
Coke	11*

* Wt.-%

listed in Table 3. After debutanization of the overhead straight-run gasoline stream the five blends shown in Table 3 are made.

The 617 b/d catalytic cracking feed shown in Table 3 will supplement the side-cut gas oil from the crude distillation unit and deasphalted reduced crude as charge to the Fluid unit. All butanes and lighter from the rerun section enter the Girbotol treater, along with light catalytic cracked gasoline and cracked wet gas production. A small motor-driven compressor will handle the fixed gas production from the reflux drum of the rerun column, discharging the stream to the Girbotol unit first stage compressor.

The straight-run stabilizer will be refluxed with feed to the tower, the overhead vapors at 65 psi. venting to the discharge of the first-stage compressor at the Girbotol unit. Two packed contact towers, one for treating liquid and the other vaporized hydrocarbons, will be used. Each takes its respective feed from the compressor discharge receiver.

The second-stage compressor takes suction through a scrubber on sweetened gas, discharging through recontacting coolers with sweetened liquids into a water separator and thence to the absorber-stripper column of the gas recovery unit operating at 225 psi. This tower is fed with heavy catalytic cracked naphtha as absorption oil with two intermediate "sponge oil" streams also being used to give a high propane recovery. The de-ethanizing which also is accomplished here eliminates the need for recycling uncondensed vapors from the reflux drum of the debutanizer which follows in the processing sequence. Residue gas is used for plant fuel. The debutanizer is a 36-tray column, producing a propane-butane overhead stream as charge to catalytic polymerization. The bottoms stream, amounting to 1915 b/sd, is debutanized cracked gasoline for blending.

TABLE 3—Streams from Rerun Tower and Straight-Run Products Blends

Stream	(b/cd)	Tractor Dist. (b/cd)	No. 1 Dist. (b/cd)	Diesel (b/cd)	Straight Run Gasoline (b/cd)	To Catalytic Cracking (b/cd)
Overhead: 250° F. EP straight-run gasoline	600	...	...	...	600	...
First side cut: 250-350° F.	798	90	...	...	708	...
Second side cut: 350-400° F.	447	90	290	20	47	...
Third side cut: 400-510° F.	622	80	145	155	...	242
Fourth side cut: 510-600° F.	416	...	...	175	...	241
Bottoms: 600° F.—plus	134	...	...	...	...	134
TOTALS	3,017	260	435	350	1,355	617

Catalytic Polymerization

The cat poly unit charges 1175 b/sd of a mixed propane-butane feed containing approximately 50 mol-% unsaturates. To insure a sweet charge, the mixed feed from the gas recovery unit is caustic and water washed. Charge is delivered at 350° F., 1150 psig, and 44 gpm.

The two reactors, in series, are of shell and tube design, containing 121 2-in. tubes 30 ft. long. Tubes of each reactor contain 4300 lbs. of Universal Oil Products Co. phosphoric acid catalyst and are water cooled to maintain close temperature control, which thereby permits charging olefin-rich gas without necessity for recycling. Space velocity is maintained at 0.24 gal. per hour per lb. catalyst.

Reactor effluent exchanges with charge and then is subsequently deethanized, depropanized and debutanized. The propane and butane are disposed of as LP-gas, with some butane also blended into finished gasoline. Approximately 400 b/sd of true polymer is made for gasoline blending, and design conversion for the unit is 85%.

Desulfurized straight-run and catalytic cracked gasoline will be Perco copper sweetened in a treating unit rated at 4750 b/d capacity. Butane will be similarly treated in a twin-case 500 b/d unit. Distillates will be Doctor-sweetened.

Plant Utilities

Water is purchased from the city of Billings and electricity from the Montana Power Co. The Fluor 4-bay induced draft cooling tower is rated to cool 12,000 gpm. of 101° F. water to 77° F. with air having a 68° wet bulb.

The water is a satisfactory coolant as purchased, but for boiler use hot soda-lime softening is necessary and "K-gel" is added as indicated by analysis. Two Henry Vogt boilers rated at 90,000 lbs. each of 650 psi. 750° F. produce the bulk of steam used, and are outside installations. Controls are Republic, and located in a nearby control room along with water treating equipment. Another boiler, utilizing waste heat from cracking catalyst regeneration, is located at the Fluid unit.

The 650-psi. steam is expanded to 175 psi. and 40 psi. through turbine drives on boiler fans, water pumps and the catalyst regeneration air blower. Additional drivers exhaust part of the 175-lb. steam to feed the 40 lb. and 20-lb. systems, the balance being used for process heating. Process stripping requirements are served by the 40-lb. system; 20-lb. steam also is used for utility heating.

All steam is condensed except that used for stripping in the crude distillation tower and propane deasphalting units.

Storage facilities total 700,000 bbls., including 438,000 bbls. for finished and intermediate stocks, 10,000 gal. of sulfuric acid and 12,000 gal. of caustic. There are five 500-bbl. LPG tanks, a 10,000-bbl. spheroid for natural gasoline and a 120,000 bbl. base gasoline stock tank. The tanks were supplied by the Chicago Bridge & Iron Co.

The vessels for the Fluid cracking unit were supplied by the Wyatt Metal & Boiler Works. Alloy-clad steels used in some vessels were supplied by Lukens Steel Co; fractionators and other vessels by Flint Steel Corp., McNamar Boiler & Tank Co. and A. O. Smith Corp.; gas compressors by Cooper-Bessemer Corp.; crude stills and other heaters by Jones & Laughlin Supply Co. and Petro-Chem Development Co.

Night view of Continental's Billings plant, showing (left to right) crude heater and flash tower with propane deasphalting in background, Fluid catalytic cracking unit and synthetic crude tower, and gas recovery and poly units

API Lubrication Meeting Debates Quality Standards for 5W Oil

THE 5W designation for the new type sub-zero motor oils should be restricted to premium or heavy-duty oils of medium to high viscosity index, until more performance data are available on low VI and straight mineral types of 5W oils. That is the suggestion made by A. B. Anglin, British American Oil Co., Ltd., before the Lubrication Group Session Nov. 9 at the recent API annual meeting in Chicago.

His paper(1) detailed field experience in Canada of his company with the 5W type oil, which is being recommended as a replacement for the 10W-grade-plus-kerosine for use in areas where temperatures may drop below —10° F.

Since 5W motor oil was first proposed in 1947, much progress had been made by his company in the development of oils of this type, he stated, including laboratory work, engine and field tests and a full winter's experience in marketing the oil extensively in cold-weather areas. "Many of the questions asked in the early stage of development have now been answered," he stated, "and at this date little doubt remains of the usefulness of the product."

Extends Startability Downward

It has been demonstrated in the short time his company has marketed this product, he stated, that the 5W oil provides a definite improvement over the 10W grade from the standpoint of startability. It has helped to extend the range of startability down to temperatures where the limiting factors are not so much oil viscosity as battery output and fuel volatility. Also, he stated, consumption and wear characteristics have been satisfactory in the service for which the oil has been recommended, viz., passenger car and light truck.

"The most important factors which apparently still require to be worked out are an evaluation of the extent to which this oil may be used in heavy-duty operations," he stated, "and whether it can be satisfactorily defined by viscosity only, or whether it will be necessary to write quality requirements into the grade classification."

"At present the 5W grade is defined only by the viscosity of 1800 sec. to 3200 sec. at 0° F.," said Mr. Anglin. "It is possible to produce within this specification oils of widely varying characteristics, some of which might not be suitable lubricants even for light passenger car service. Until more data are available on the performance of low VI and straight mineral types of 5W oils, it is suggested that the 5W designation be restricted to premium or heavy-duty oils of medium to high viscosity index.

"Although this may be objected to, on the grounds that it is introducing a quality requirement into a classification system which is intended to indicate viscosity only, the fact should be recognized that, in order to secure an oil with the desired low-temperature characteristics, certain properties such as the viscosity at engine operating temperature and load-carrying ability—are approaching, or going below, the minimum requirement for safe operation. This situation does not exist with the heavier grades.

"It has been demonstrated that 5W premium oils of high VI are satisfactory. This has not yet been proved for low VI or straight mineral oils, so far as is known. If 5W oil is to be adopted, either by the automobile manufacturers or the Society of Automotive Engineers, as an industry standard, it would appear that this should be with a quality requirement included, or at least until such time as it is shown to be unnecessary."

In discussing the Anglin paper, H. C. Mougey, Technical Director, Research Laboratories Division, General Motors Corp., suggested(2) the oil companies in the U. S. follow the same policies in introducing the 5W oils in sub-zero territories as have been used in Canada. The Canadian oil and automotive representatives, in planning for the distribution of 5W oils in the 1949-50 winter, Mr. Mougey said, had set up the following policies:

"1. That the oil shall be called '5W' oil.

TABLE 1—Typical Inspection of 5W Motor Oil

API gravity at 60° F.	34.0
Flash point (Cleveland open cup), ° F.	380
Saybolt Universal viscosity (seconds), at:	
100° F.	117.2
210° F.	41.95
0° F. (extrapolated)	3,200
—20° F. (extrapolated)	10,000
300° F. (extrapolated)	34.2
Viscosity index	132
Acid No.	0.027
Pour point, ° F.	—40
API designation	Premium type

"2. That the viscosity at zero shall be kept within the limits of 1800 sec. to 3200 sec., Saybolt Universal.

"3. That it shall be in the recommendation for 'premium' grade.

"4. In recommending 'premium', that the oil supplied by the oil companies will have such viscosity characteristics as to be conducive to good oil consumption and to improved protection in the higher temperature ranges, and that the oil will be suitably inhibited against oxidation.

"5. That the oil will be recommended as a replacement for 10W plus kerosine, and that it will not be recommended as an all-around winter lubricant replacing 10W.

"6. That 5W should not be diluted with kerosine or other diluents."

Although the SAE has not taken formal action in regard to 5W oil and, consequently, at this time it is not an official SAE classification, said Mr. Mougey, a number of the automobile manufacturing companies are recommending 5W in the car owners' manuals, and a number of companies are marketing 5W oil in this country.

In Viscosity Terms Only

Mr. Mougey pointed out that the SAE classification of motor oils is in terms of viscosity only, and that other factors of oil quality or character are not considered.

"When and if the SAE takes official action in regard to 5W," he stated, "it would be possible, according to SAE rules, to cancel this restriction and to specify a number of 'quality' requirements, but I do not think that either the oil or automotive industry feels that this should be done at this time."

Carl W. Georgi, Quaker State Oil & Refining Corp., in discussing the Anglin paper,(3) also expressed disagreement with proposal that the classification of 5W oil include not only viscosity limits, but also specifications as to quality. On this point Mr. Georgi stated:

"Suggestions that rigid specifications be set up for motor oils or other lubricants, whether these originate from within or without our industry, always imply (to me at least) that petroleum refiners and marketers are so ignorant, or so careless, of their responsibility to the consuming public, as well as of their own welfare, that they need fixed and rigid rules for making their products. Cer-

TABLE 2—Summary of Test Data, Cars, Controlled Field Tests—5W Motor Oil

Unit	9635	9648	9547	9635	9426	9420	9531	9605	9822	9814	9801	9379
Date test commenced	March 1	Feb. 27	Feb. 28	Feb. 25	Feb. 20	Feb. 20	Feb. 29	Feb. 25	March 17	Feb. 29	March 15	March 16
Date test finished	June 5	June 19	May 14	June 19	May 22	June 27	March 27	March 20	April 18	May 7	May 16	April 9
Total test mileage	5,340	4,434	3,332	6,645	5,862	6,852	610	1,213	1,964	4,791	1,713	1,344
Type of driving	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed	Mixed
O.l-change period, miles	1,068	1,478	833	1,329	977	1,142	610	1,700	1,964	1,597	1,713	1,344
O.l consumption, miles/qt. (Imp.)	483	944	508	751	549	1,115	305	1,700	982	1,063	856	1,344
Used-O.l Examination:												
Saybolt Univ. visc. at 100° F., sec.	111.1	113.2	104.5	111.2	111.7	104.9	101.7	105.6	114.2	117.4	115.0	112.0
Saybolt Univ. visc. at 210° F., sec.	41.83	40.85	40.61	41.19	41.37	40.92	40.34	40.88	41.33	41.69	41.50	41.30
Pour point, ° F.	—39	—40	—41	—42	—45	—43	—45	—40	—45	—42	—45	—45
Acid No., mg. KOH, per gram	0.62	0.46	0.89	0.48	0.79	0.39	0.40	0.56	0.87	0.59	0.41	0.21
Water, %	Trace	Trace	Trace	Nil	Trace	Trace	1.0	Trace	Nil	Trace	0.05	Trace
Naphtha-insolubles, %	1.051	0.375	1.437	0.134	1.247	0.171	0.504	1.195	1.624	0.073	0.076	0.057
Chloroform-solubles, %	0.110	0.034	0.065	0.033	0.066	0.017	0.047	0.043	0.134	0.026	0.015	0.040
Dilution, %	3.0	2.0	4.9	2.9	2.7	3.3	6.8	2.4	2.4	2.5	3.6	2.0

tainly, the industry's record of supplying quality products, and of constant quality improvement, does not justify such thinking, suggestions or implications.

"In the first place, quality specifications invariably tend to become fixed and rigid. (I use the term 'rigid' as defined by the dictionary as 'inflexible or resisting change'). The record of our industry, in the vast sums spent yearly for research and development as well as for the continual advancement in quality improvement, is the exact opposite of anything suggesting rigidity or resistance to change.

"The research and development departments of the oil industry, as well as the men who market oils and who thereby accept responsibility for their performance, are thoroughly familiar with the quality requirements of motor oils, and with the particular emphasis on quality required in the very light 5W grade. I am confident that the 5W oils now being marketed, or to be marketed in the future, will fully meet or exceed the quality requirements of service performance—without resort to formalized and rigidized quality specifications."

Development of 5W Oil

Mr. Anglin, in his paper gave the following resume of the experience of the British American Oil Co., Ltd., in developing a suitable oil of this type: (Table 1 is a typical inspection of a 5W oil.)

"Initial development of our oil was the result of many discussions between the manufacturing, research, and marketing departments. When agreement finally was reached by these departments, an experimental quantity of base stock was produced; and blends of this were tried out with various additive combinations to produce desired results in physical specifications and laboratory engine performance.

"The final decision was to make up a narrow-cut base stock from Mid Continent crude with a Saybolt Universal viscosity of approximately 100 sec. at 100° F. This, when the additives were put in, would come out at the required viscosity range 1800 sec. to 3200 sec. at 0° F.

"However, the base stock was finished to 95 viscosity index. Inasmuch as it was felt that as high a viscosity as possible at the engine operating temperature was desirable to prevent scuffing and/or bearing wear, a VI improver was added to give 130 VI. This resulted in a finished oil with an extrapolated viscosity of 34 sec. at 300° F., or only slightly less than our 10W. Pour point was to be as low as possible, and it appeared that —40° F. was as low as could be secured from this type of stock with conventional pour depressants. To be certain of a stable pour point, with no possibility of wax precipitation, as well as to remove waxes, which might readily oxidize in service, the base stock was dewaxed to a pour point of —5° F.

"Finally, inasmuch as it is well known that light-viscosity oils oxidize more readily than heavy, a greater amount of oxidation and heavy corrosion inhibitor was added than was regularly used in heavier stocks of the same type.

Laboratory Engine Testing

"After blends with the required physical characteristics had been secured, they were subjected to full-scale engine tests, using Chevrolet L-4 procedure modified to a crankcase temperature of 250° F. In these tests, oil stability—in terms of sludge, varnish, bearing corrosion, viscosity, and neutralization-number increase—was evaluated. Also checked was the stability of the VI improver, and oil consumption was noted.

"Results of laboratory engine tests confirmed our original thoughts regarding the required characteristics. The light-viscosity base stock needed considerable inhibiting to hold bearing corrosion within acceptable limits —more so than heavier stocks of the same general type. In the L-4 test, bearing corrosion was the first indication of oil breakdown. This had appeared even before there was any appreciable indication from increase in neutralization number or viscosity. Excellent sludge- and varnish-cleanliness ratings were secured, even where high bearing corrosion was encountered because of insufficient inhibitor. Tests were made with various inhibitor contents in order to establish the correct amounts. High bearing-weight losses, when insufficient inhibitor was used, forcibly indicated the need for proper inhibition of these light-viscosity stocks.

"Blends proved to be stable in viscosity characteristics, it is believed, because of the fact that the base stock was a high flash-point narrow cut, containing no light volatile fractions.

"Viscosity index decreased only slightly in laboratory engine tests, and that satisfactory VI stability is possible with the VI improver used as indicated.

"Wear data, aside from bearing-weight loss, were not determined in laboratory engines. It was simply observed that there was no indication of abnormal wear in any engine parts during the course of the test."

The British American Oil Co. carried on extensive field tests with the 5W oil before putting it on sale commercially, and the results were described by Mr. Anglin as "highly satisfactory." In the tests 16 vehicles, both cars and trucks in company service, were operated a total of 75,000 miles. Starts were made at temperatures below —40° F. after standing overnight. The percentage of successful starts at temperatures below —20° F. was considered excellent. Table 2 is a summary of data from a field test program.

Wear data were secured on two passenger cars using 5W oil, both equipped with new engines at the start of the test. The vehicles were run 10,000 miles and then inspected, which meant the 5W oil was used in the vehicles under summer operating temperatures for a considerable period, it was reported. Examination of the engines showed no indication of any abnormal wear whatever.

References

(The following papers were all presented before the Lubrication Group Session, under the auspices of the Division of Marketing, Nov. 9, during the 29th Annual Meeting of the American Petroleum Institute in Chicago.)

(1) "Field Experience with 5W Motor Oil," by A. B. Anglin, British American Oil Co., Ltd., Toronto.
(2) Prepared discussion, by H. C. Mougey, Technical Director, Research Laboratories Division, General Motors Corp., Detroit.
(3) Prepared discussion, by Carl W. Georgi, Quaker State Oil Refining Corp., Oil City, Pa.

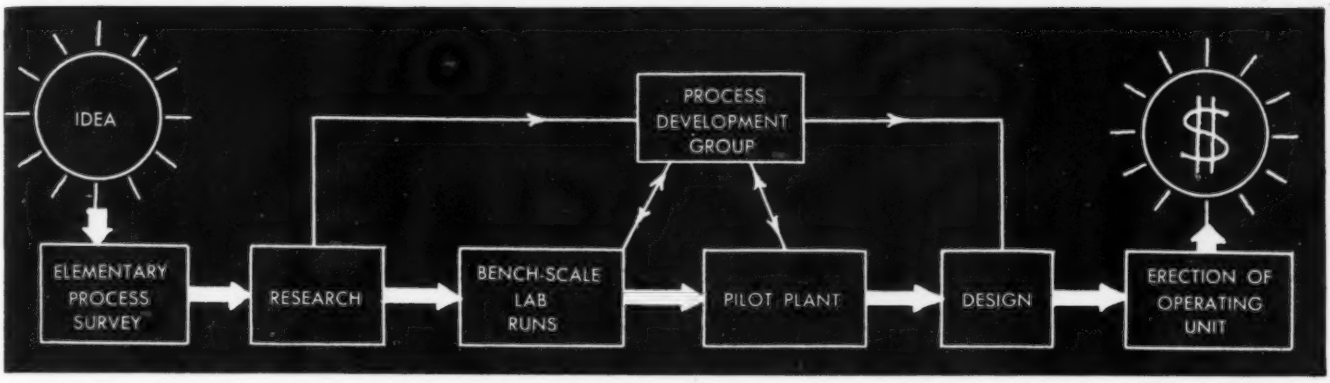


Fig. 1—Steps in the development of a petroleum refining process

Petroleum Processing Pilot Plants

By MARSHALL SITTIG, Chemical Engineer, Detroit

An up-to-date literature survey is presented on pilot plants as part of an overall process development program. Experience of chemical manufacturing concerns with pilot plants is referred to, also the trend toward standardized equipment for them. The use of pilot plants in specific petroleum refining processes is developed.

PILOT plants assume particular importance in the petroleum industry due to the large sizes of petroleum processing units. Where pounds per hour have been the criterion of size in the chemical industry, barrels per day—a factor more than ten times as large—has been the yardstick for our huge refinery units. Thus, the degree of extrapolation from test tube to full scale has been greater in the oil industry, placing increased dependence on the results of pilot plant tests.

The pilot plant is, of course, but one step in an overall process development scheme. Placing proper emphasis on the pilot plant step as such, however, demands an appraisal of the overall scheme so that optimum effort may be expended on each step. Fig. 1 outlines the function of a process development group which can coordinate the various steps in the overall program and insure the maximum economy in the pilot plant and other stages.

The place of the pilot plant in the overall process development picture has been discussed recently by Hitchcock[1], who emphasizes the tie-in with final marketing problems of a chemical company. Other recent discussions on the functions of pilot plants include those by Harris[2], Brown[3], Barnebey[4], Vilbrandt[5], and Swezey[6].

The importance of economic evaluation at the pre-pilot plant or bench-scale stage has been discussed by Harris[2], and was the theme of a recent paper by E. C. Dybdal[7] of Monsanto Chemical Co. R. B. Semple[8], also of the Monsanto organization, has discussed a trend toward less elaborate and expensive pilot plants in the chemical industry. The application of reaction kinetics has gone far to permit determination of specific kinetic data in a few chosen runs as a basis for process design—eliminating a great many relatively hit-or-miss experiments which at one time characterized pilot plant operation. The application of statistical analysis to the results of pilot plant tests[9] is another way of getting maximum benefit from the data at hand.

Provides Equipment Design Data

Aside from process design data, pilot plant operation is still necessary to obtain equipment design data, such as corrosion and erosion data. Fontana[10], in a series of three monthly columns, has summarized the various aspects of pilot plant corrosion testing.

One variation of the trend toward lower-cost pilot plants has been the evolution of standardized or "packaged" pilot units.

"Packaged" pilot plants have been advertised, to quote a few typical examples, by Blaw-Knox[11], who have designed a 5-gallon resin pilot plant kettle complete with instruments and accessories, and by the Patterson Foundry & Machine Co.[12]. The latter organization has prepared an assembly centering around a 10-gallon reaction vessel which can be operated at temperatures from 100 to 750° F. and at pressures from full vacuum to 100 psi. in the conduct of distillation processes, polymerization processes in resin manufacture and so on.

For continuous operation of petroleum refining processes on the semi-works scale, the present trend is toward standardized equipment. Gwin and Yule[13], of Humble Oil & Refining Co., have discussed a setup which may be used for polymerization, alkylation, isomerization, olefin hydration, catalytic dehydrogenation, and caustic treating. They have presented illustrations of interchangeable fixed-bed, mixing-type, and jet-type reactors as well as standardized auxiliary equipment including a gas-metering system, a still for drying feed stocks, a caustic scrubber for reactor products, and a pumping arrangement for corrosive liquids.

Subsequently, J. A. Ridgway, Jr. of Pan American Refining Corp. has published data[14] on standard designs for pilot plant equipment. A high-temperature and low-temperature electric heater, heat exchanger, proportioning sampler, and a liquid displacement meter are illustrated in the above reference as examples of standardized pilot plant equipment. Bench-scale equipment, often hard to differentiate from its larger cousin, the true pilot plant equipment, may be made up of standardized components, as outlined by Henriques[15] of Shell Development Co. Elimination of delays with consequent savings in semi-works expenditure is possible through the use of such "building-blocks".

The question of standardized housing for particular types of chemical process pilot plants, bordering on the petrochemical field, has been undertaken by the B. F. Goodrich Co. in their new research center at Brecks-

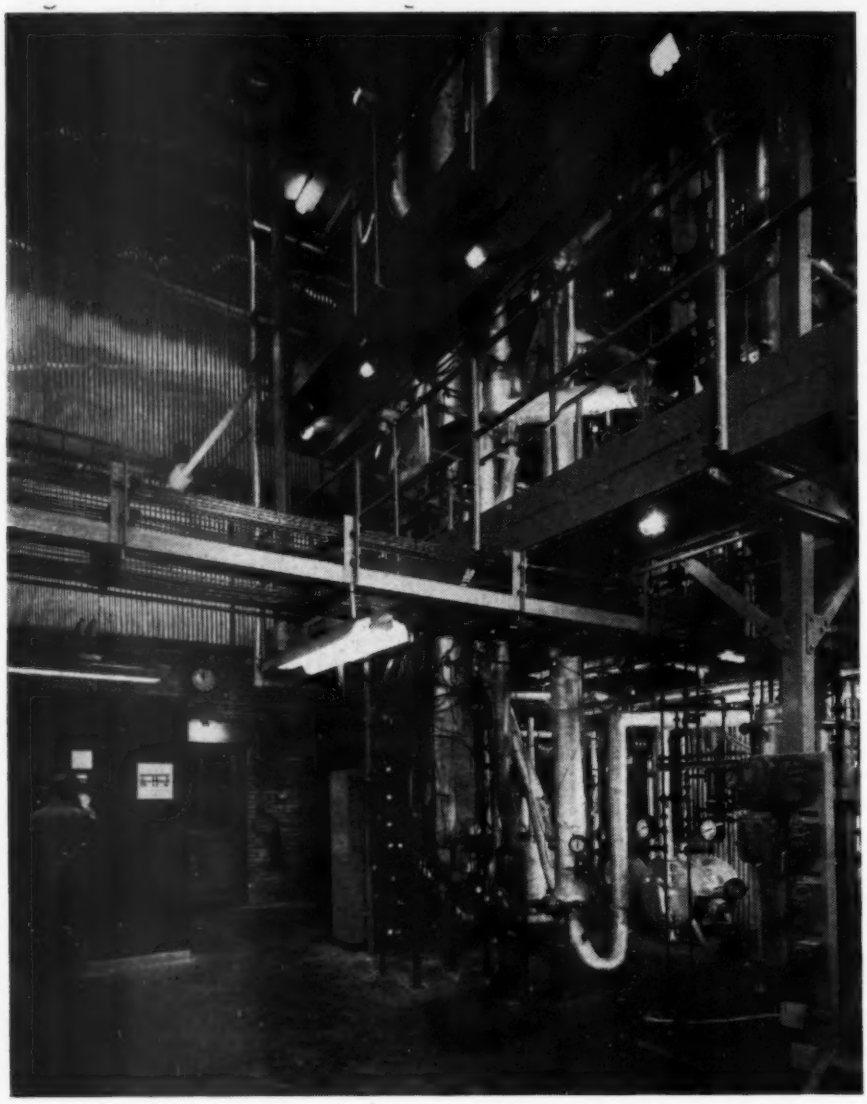


Photo courtesy of The Austin Co.

Typical pilot plant for work on Fluid catalytic cracking at Sinclair Refining Co.'s new laboratories in Harvey, Ill.

ville, Ohio[16]. They have constructed what they term a "Hi-Vent" building specially designed for work with toxic chemicals and a "Hi-Pressure" building for barricaded high pressure operations.

Let us turn now to specific petroleum refining processes and the particular pilot plants used in their study.

Catalytic Cracking

This process has been the recipient of much pilot plant investigation over the last several years. The many huge commercial units representing enormous investments, have demanded careful piloting in both design and subsequent operation with different catalysts on varying feed stocks.

One variation of catalytic cracking, in the broad sense of the term, is catalytic dehydrogenation. The catalytic dehydrogenation of normal butane has been the subject of considerable and thorough research. Dodd and Watson[17] have reported on pilot plant operation with emphasis on the application of reaction kinetics to a relatively small number of pilot plant runs. Other work on this reaction has been described by Hachmuth and Hanson[18] of the Phillips Petroleum Co. The Phillips installation was quite large (a 10-ft. direct-fired catalyst tube being employed) in contrast to Dodd and Watson's equipment (an electrically-heated tube containing 50-200 cc. of catalyst) which was more nearly bench-scale.

The subsequent reaction of dehydrogenation of butene to butadiene has been discussed from the kinetic standpoint by Beckberger and Watson[19]. Again, their report has been complemented in the literature by an industrial report on Esso experience with a 10-ton per day pilot plant at Baton Rouge[20].

With regard to pilot plants for the major catalytic cracking processes, most information has probably been published on fluid catalyst pilot units. Carlsmith and Johnson[21] divulged some of the first information. Subsequently, Nicholson, Moise, and Hardy have summarized Esso experience[22] with fluidized solids pilot plants.

Universal Oil Products Co. has published[23, 24] descriptions of their fluidized solids, semi-works unit. A well-illustrated description of the Humble Oil & Refining Co. "kitten" cracker has been published[25]. Trainer, Alexander, and Kunreuther, of Shell Oil Co., Houston, published a detailed description of their fluid bed catalytic cracking pilot plant[26]. Diagrams of a catalyst slide valve, an instrument line catalyst trap, a gas sampling device, and the filter housing for the catalyst regenerator have been presented.

Among the dynamic-bed catalytic processes, Thermofor cracking has necessarily been the subject of much pilot plant evolution on the road to the giants which mark our refinery skylines. Eastwood, Hornberg, and Potas[27] presented a detailed description of one of their pilot units at the Paulsboro, N. J., laboratories. Thermofor pilot plants in general have not strictly copied the parent units in the use of catalyst elevators. Rather, the pilot units have utilized batchwise catalyst transfer in large hoppers which serve as feed hoppers or receivers for kiln or reactor, being transported by crane from point to point.

A suspensoid cracking pilot plant has been described by Flanagan[28].

A hydroforming pilot plant has been described by Yule and Bennett[29]. Details of construction of another hydroforming pilot plant, together with details of operation of the unit, have been written up by Berg, Fawcett, and Dhondt[30] of Union Oil Co. of California.

Generalized information on various equipment components for the evaluation of vapor-phase reactions with solid catalysts has been published by Henriques[15] of Shell Development Co. Also, Komarewsky and Riesz, in a new second volume of the series on "Techniques in Organic Chemistry"[31] have given detailed information on constructional details of bench-scale equipment for catalytic reactions. They devote a large part of their discussion to high-pressure flow apparatus.

In spite of heavy current emphasis on catalytic processing, research and development on thermal conversion continues. Kelso and Snyder have recently described a pilot unit[32] for the thermal conversion of hydrocarbons at high temperatures and pressures. Lukashevich and Smidovich have described a bench-scale setup for the study of thermal cracking in

a recent Russian book[33] on laboratory techniques for the petroleum industry.

Alkylation

Information has been presented on a variety of alkylation pilot units. Johanson and Watson[34] have described a pilot plant for catalytic production of toluene from a mixed benzene-xylene feed. The Russian authors mentioned above[33] have described a bench-scale unit for the alkylation of benzene with propylene in the presence of sulfuric acid. Bowerman and Filbert, of Humble Oil and Refining Co., have described a jet-type reactor alkylation unit in detail[35].

Lube Oil Refining

Knox, Weeks, Hibshman, and McAteer, of Esso Laboratories, have published detailed descriptions of batch and continuous equipment[36] for both liquid-liquid and vapor-liquid extraction processes. The lubricating oil pilot plants in the Foster-Wheeler research laboratory in Carteret, N. J., have been described and pictured in the literature[37]. The design and operation of Socony's lube oil solvent extraction pilot plant has been described[38]. Lukashevich and Smidovich[33] describe a small-scale solvent extraction unit, a propane deasphalting unit, and a solvent dewaxing unit.

Petrochemicals

A field of increasing importance within the broad scope of petroleum process pilot plants is that of petrochemical pilot plants. Here we encounter the oft-mentioned difficulty of defining a "petrochemical". The new high-pressure acetylene pilot plant of General Aniline and Film Corp.[39] and polymerization pilot plants for synthetic rubber manufacture[40] are examples in this field.

Photo courtesy of Phillips Petroleum Co.

Extensive use of glass in synthetic rubber polymerization pilot plant at Phillips Petroleum Co. laboratories

The application of hydrogenation to the manufacture of xylidines by Esso has been described in detail in a series of three articles which follow through the stages of process development[41, 42, 43].

A thorough follow-through from exploratory laboratory equipment through bench-scale to pilot plant equipment in Shell Chemical Co. manufacture of acrylonitrile by the oxidation of allylamine has been printed recently[44].

Synthetic Liquid Fuels

Recent work on coal gasification is typified by the pilot plant of the Pittsburgh Consolidation Coal Co.[45], built in cooperation with Standard Oil Development Co.

Some excellent descriptions of Bureau of Mines pilot plant equipment for the manufacture of oil from coal are now available in a copiously illustrated government report[46], available free for the asking.

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SAFETY in the TURNAROUND

Shutting Down Processing Units and Putting Them Back on Stream Again, in Utopia Refinery, Calls for Special Attention to Many Potential Working Hazards

By F. J. SLUZE
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Ashland Oil & Refining Co.

A refinery cleanout, shutdown or turnaround, as it is variously known, is no haphazard, hit-or-miss operation in a modern refinery. On the contrary, it is a well planned and coordinated activity in which the plant Safety Department should play an important role. Here is how the operation would be scheduled in Utopia Refinery, where safety matters are "top drawer" in all plant functions.

Weeks ahead a board of strategy consisting of the refinery superintendent, chief engineer, safety director, process superintendent, metal inspector and maintenance superintendent hold a series of conferences to organize the job.

A list of the special jobs to be done in the turnaround is drawn up. Another list sets forth the routine work done during every shutdown. A third list shows the location of every blind, which expedites the inserting of these blinds or blanks when the unit comes down.

Get Safety Supplies Ready

During the preliminary stages of preparation the safety director checks on the availability of safety supplies such as goggles, non-spark tools, respirators, flange spreaders or jacks, permissible lights, asbestos gloves for exceptionally hot jobs and air movers. He is also busy passing judgment on the quality of scaffolds and ladders that are being set up for the cleanout, puller jacks, ropes, hoisting equipment such as tuggers, cranes and winch trucks, air and steam hoses, to see that all of these items of equipment are in safe working condition. Should he detect any defects he orders correction or replacement of the equipment before it is put into use.

After the board of strategy has laid the ground work for the turnaround, the maintenance superintendent calls in his several craft supervisors and acquaints them with the general plan. The work entailed is then broken down into several phases.

The pipefitter foreman concentrates on arranging for inserting blanks, removing designated sections of pipe, removing tube bundles from condensers or heat exchangers, and rigging work. The mechanical or machinist foreman focuses his attention on pump, compressor and valve repairs, and on governors and overspeed trips.

The instrument foreman is prepared to inspect, test, and repair recorders, control valves, gauges, indicators and other such instruments and devices. The electrical foreman is ready for inspection, repair or replacement of motors used in processing. He has in readiness extension cords, lights and portable electric tools that have been checked to make sure they are in safe condition. The welding foreman lines up his force for the different welding and burning operations necessary for successful prosecution of the turnaround job.

Two other foremen have special assignments. One is responsible for unheading towers and vessels in preparation for cleaning out coke, sludge and residue from these vessels and towers; the other for reaming out coke from the furnace tubes and other lines that gather coke. However, before these sub-divisions of the maintenance department can proceed with their actual work the processing unit must be shut down and made ready for these wholesale repairs. Careful attention is given to safety provisions in this operation.

First the oil is withdrawn from the unit and then it is cooled down by pumping down all levels gradually. When the pumping down is finished steam is introduced into the towers for a period of five to eight hours in order to dilute and render harmless any gas or vapor inside. Water is sometimes pumped into towers to cool them off and it must then be pumped out. The insertion of blanks is the next operation after normal temperature are realized. Safe practice requires that these blanks be placed in the line as near the tower as is practical, where they give positive protection against oil, gas or steam seeping into the tower while men are working inside. Valves alone are not dependable since they have been known to leak and permit seepage which caused accidents.

Gas Free Tests Made

As soon as the blank have been inserted, the operating superintendent notifies the safety engineer, who makes a test of the atmosphere inside these towers with a petroleum vapor indicator to determine whether or not the vessels are gas free. The presence of 0.012% of gas classes the tower as still unsafe, and further steam purging may be necessary. If the tower is gas free, the safety engineer notifies all concerned. While performing his gas test the safety engineer also double checks on blanking to make certain that men required to enter vessels are fully protected. Throughout the turnaround the safety engineer makes frequent tours of inspection observing working practices and looking around for potential hazards such as are given in the accompanying table:

To provide ventilation within a tower or vessel and keep working conditions comfortable for the workers, an air mover is placed at the upper manhole. This induces an air

Where's Utopia?

The author's mythical "Utopia" Refinery, described in this article, has been inspired by Sir Thomas Moore's now famous account of the Mythical Island of Utopia, where the inhabitants lived in the enjoyment of social, political, and industrial perfection. Such utter perfection may well be considered the ideal goal of today's petroleum processing plant.

Readers may recall an earlier series of articles by Mr. Sluze written in the same vein and describing other accident prevention activities in the "dream" refinery where nothing could go wrong. These articles appeared in Petroleum Processing during 1947 and covered such topics as fire prevention, welding practices, pipefitting, tank cleaning, electrical operations, and the like.

Personal protection is a must during cleaning of vessels in Utopia

circulation into the vessel or tower by means of air ejection.

By this time all sub-divisions of the cleanout organization have gone about their respective assignments. The metal inspection force has also gone to work inspecting all piping in the unit. The metal inspector appraises the condition of the equipment by many means, among them hammer testing, calipering, gauging, sentinel drilling, remotomike reading, and in some instances by means of audio gauge.

In the removal of coke from furnace tubes a cone shaped head is used as a coke reamer. This reaming requires skill and experience since the reamer must not be allowed to remain at any one place in the tube too long because it will wear away that part of the tube and create a weakness due to thin tube wall. A special safety precaution in connection with this work is a curtain hung on the far side of the tubes to act as a buffer against flying reamer heads and particles of coke. Another safety provision is in making sure that the scrapers and chisels used to remove coke and sediment from the walls and trays are low-spark material. All trays, walls and bubble caps are scraped clean of sediment, coke and residue.

Check Valves, Pumps

Relief valves must be put in safe operating condition for the next run, so their condition is determined by a standard pressure test. The pump mechanics take apart pumps and repack and reline them, and make other repairs found necessary. Safety provisions require they first bleed off the pressure and that the suction and discharge of the pump be closed and the bleeder valve be left open. The precaution is taken to lock out and flag out the source of power. The pump mechanic is the only person authorized to remove the lock and danger flag, so there is no danger of anyone starting up the equipment while he is working on it.

All welding and cutting jobs throughout the cleanout operation are controlled by a standard hot work permit.

Before starting up the unit again, both the routine and special work lists are checked by operating superintendent, maintenance superintendent and the safety director to make sure that the work listed on the planning schedule has been satisfactorily completed. A thorough visual inspection is made by these men to make certain that everything has been placed back in safe operating condition. The next step is to make sure that all blanks have been removed.

Start-up requires first putting through an oil charge to pressure test the system. This pressure test will disclose any leaks that may be present in tubes, piping, manheads or valves. If no leaks have been discovered, the circulating and heating is begun and is continued for about five or six hours and then regular processing gets under way. During the early period of resumption of operation, personnel in the unit is kept to a minimum in order to expose as few persons as possible to any danger that may develop. Fire fighting facilities are also kept in readiness.

Once the unit is back in operation, preparations for the next cleanout are begun. The welding department proceeds with the fabricating of new pipe which it is known will be required. Tube repairmen begin retubing condenser and heat exchanger bundles for future replacement. Electricians repair extension cord equipment and electric welding machines damaged during the cleanout as well as motors taken out of service through replacement.

Nine Potential Working Hazards in Turnaround

1. Tripping hazards due to hose or cable crossing walkways or stairways.

2. Faulty lashing or rigging of loads.

3. Slippery walking surfaces due to oil spills.

4. Falling object hazards due to faulty placement of materials or tools.

5. Faulty ventilation in towers or vessels.

6. Failure to place warning signs at approaches to overhead work.

7. Failure to wear prescribed protective clothing or equipment.

8. Electric shock hazards.

9. Unauthorized hot work.

Vacuum Pipe Still Supplies 23,000 b/d Gas Oil Charge for Cat Cracker

By J. MARSHALL NAUGLE, Process Engineer,
Esso Engineering Dept., Standard Oil Development Co.

Improved feed preparation at the Bayway refinery of Esso Standard Oil Co. is secured by means of a 49,000 b/d design capacity vacuum pipe still, which serves the dual purpose of reducing the quantity of residuum requiring further processing, and produces heavy gas oil for catalytic cracking. The 93-ft. tower of the still comprises three sections: 1) lower or stripping, 2) center consisting of a flash zone, wash section, and lower pumparound and product-condensing and removal section, and 3) upper pumparound and product-condensing and withdrawal. Feed stock, after preheating, is raised to 800° F. in a standard SOD double end-fired box type furnace.

A NEW vacuum pipe still, rated as one of the largest in the world, has recently been completed and put on stream at the Esso Standard Oil Co.'s Bayway, N. J. refinery.

The new unit was designed to process 49,000 b/sd of a composite reduced crude cut to a 41.5% bottoms in the atmospheric pipe stills. Feed to the unit is reduced to about 22% bottoms on whole crude for a yield of 26,000 b/sd of pitch bottoms; 23,000 b/sd of heavy gas oil is taken in two sidestreams and will be used as part of the feed stock for the new 41,000 b/sd fluid catalytic cracking unit being installed at Bayway. To accomplish the reduction to heavy bottoms, the tower was designed to operate with flash zone conditions of 65 mm. Hg. abs. and 775° F, with superheated exhaust steam introduced into the tower stripping section.

Design

Based on the refinery planning work, a specification of the vacuum pipe still requirements was drawn up, giving the design basis, essential utility information, and special recommendations with respect to equipment and processing. C. F. Braun and Co., Alhambra, Cal., was chosen to do the design and construction work, with Standard Oil Development Co. taking the responsibility for the process engineering. Table 1 lists the principal design conditions.

In the course of design work, careful consideration was given to include many features that would make the unit easy to operate. Several of these features are as follows. Provisions were made to spare all pumps. Only the top pumparound reflux and product pump and the bottom pumparound product pump have a common spare. Since all pumps are motor-driven and because of the possibility of local distribution center electrical failures, power is supplied through two separate yard distribution systems. In the event of power failure in one feeder circuit, the load is automatically transferred to the other system.

To minimize plugging difficulties with the high pour stocks being handled, all instrument leads have been steam traced and insulated, transmitters have been enclosed in steam heated, weather-proof cases, and level controllers and gauge glasses have been provided with continuous flushing oil blowback. Separate flushing oil connections have been provided at the discharge manifolds of hydrocarbon pumps in similar service to clear the lines of high pour stocks on comedown. Pump warm-up lines have been provided on all pumps. For a spare pump in standby service, hot fluid can be circulated back through the idle pump into the suction line. When a pump is removed from service, oil from the discharge of the operating pump can be bled back into the suction line to keep suction and discharge laterals warm at all times.

To provide for continual operation of the cooling water supply, dual motor-driven strainers have been provided. These strainers remove foreign matter from the 13,500 GPM of salt water brought to the unit in a 24-in. main.

Construction

The site chosen for the vacuum pipe still was a cleared area 358 x 145 ft. adjacent to the atmospheric distillation units. An early delivery of heater tubes, header boxes, fire brick, and castings—much earlier than structural steel for the furnace could be delivered—was turned to advantage. The end burner walls were erected, leaving pockets in the brick work for the column bases. Pairs of tubes were rolled into a common header, making very large hairpin assemblies that were stock piled for final erection after the tube sheets had been delivered and put in place.

All welding on the vacuum pipe still was done by hand. Vacuum column sections were welded on the ground to form cylinders and were hoisted into place and the horizontal seams completed. Welding was subjected to continuous inspection as the work progressed.

On the clad interior of the vacuum column, butt welds on the cladding were inspected by the Zyglow method. Faulty welds were thus readily spotted and corrected to give a tight leak-proof cladding.

The Zyglow method of inspection consists of painting the metal surface with an ultra-violet sensitive fluorescent oil, washing the surface to remove the oil coating, and then subjecting the surface to ultra-violet light. Any metal crack of flaws are readily evidenced due to the oil remaining in the cracks rather than being removed in the washing step.

It is a patented process for testing welds developed about five years ago by the Magnaflux Corp. It is used extensively, particularly in the aircraft industry, and is considered espe-

TABLE 1—Design Conditions for Vacuum Pipe Still

Whole Crude Feed	
°API	27.1
B/SD	118,000
Atm. Reduced Crude	
°API	11.6
B/SD	49,000
% on Crude	41.5
Vacuum Unit Total Gas Oil	
°API	16
B/SD	23,000
% on Crude	19.5
Vis. SSU/210	82
Vacuum Bottoms	
°API	7
B/SD	26,000
% on Crude	22
Vis. SSF/210	1400
Feed to Unit, °F	430
Feed to Coil, °F	595
Coil Outlet, °F	800
Flash Zone, °F	775
Bottoms, °F	730
Tower Overhead, °F	175
Tower Flash Zone, mm. Hg. Abs.	65
Tower Pressure Drop, mm. Hg.	21

cially useful because it may be applied to all materials, magnetic or non-magnetic; for example, with ceramic materials.

The vacuum column, after complete assembly, was hydrostatically tested with water. All other vessels and pipes were pressure tested with water and washed down.

Major Equipment

Salient features of the major equipment are summarized in Table 2. Since interest in pipe stills is generally centered on the tower and the furnace, these pieces of equipment have been described in more detail below.

As with all pipe stills, the fractionating tower dominates the vacuum unit site, rising 110 ft. above grade. The column, 93 ft. in overall height, consists of three sections of different diameters.

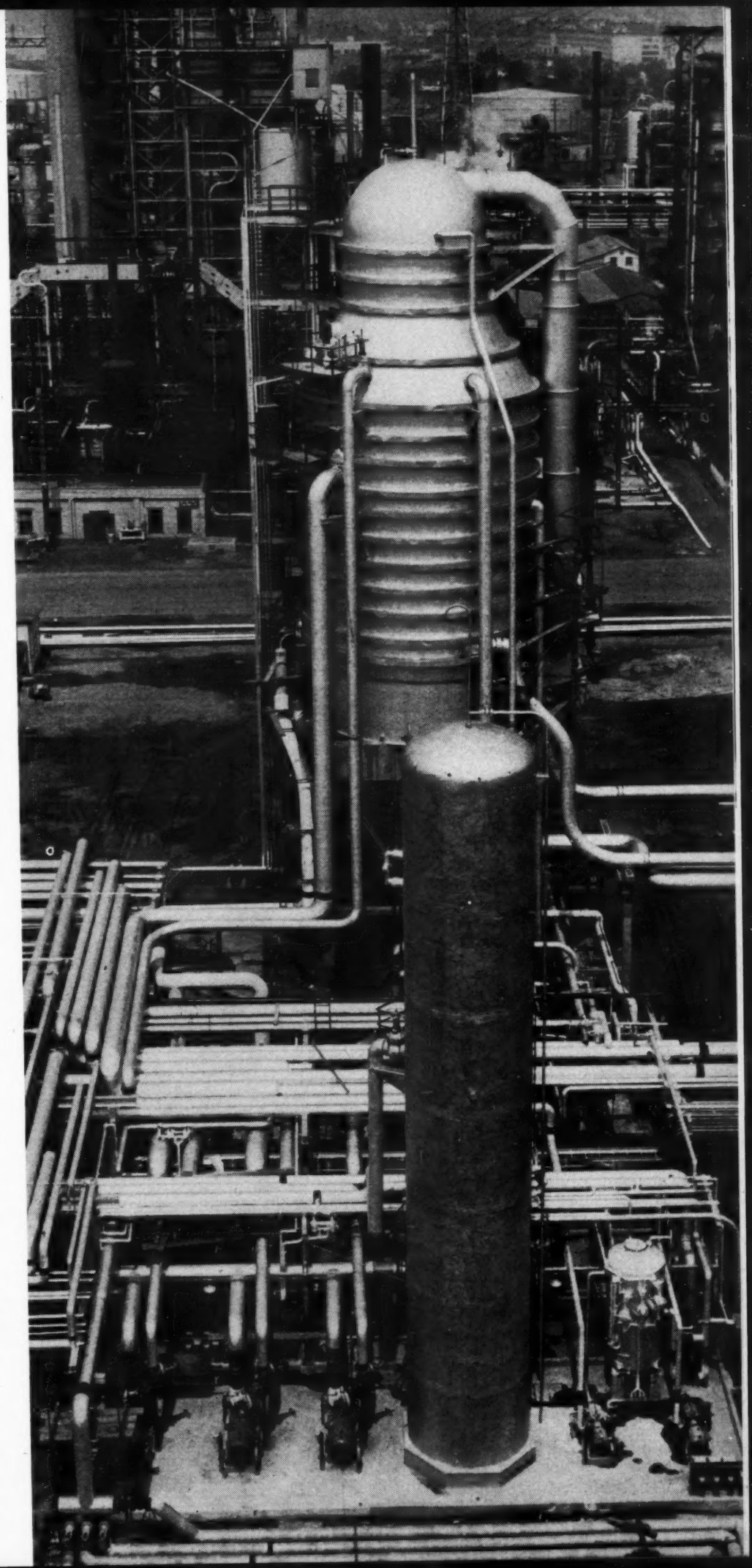
The center section, 27 ft. in diameter, makes the column the largest fractionating tower in the Jersey interests. This portion of the tower contains the flash zone, and the bottom pumparound reflux and product condensing and withdrawal sections. Two double-pass plates provide the contact surface required to condense part of the product gas oil vapors.

Liquid flow across these plates is from a center reflux distributing weir on the top plate to two overflow weirs at opposite edges of the plate. Liquid drops to the next lower plate through the two outer downcomers and flows across the plate to a center overflow weir. Bottom pumparound reflux and product is collected on a drawoff pan. This pan contains no bellcaps but is equipped with vapor risers for vapor passage.

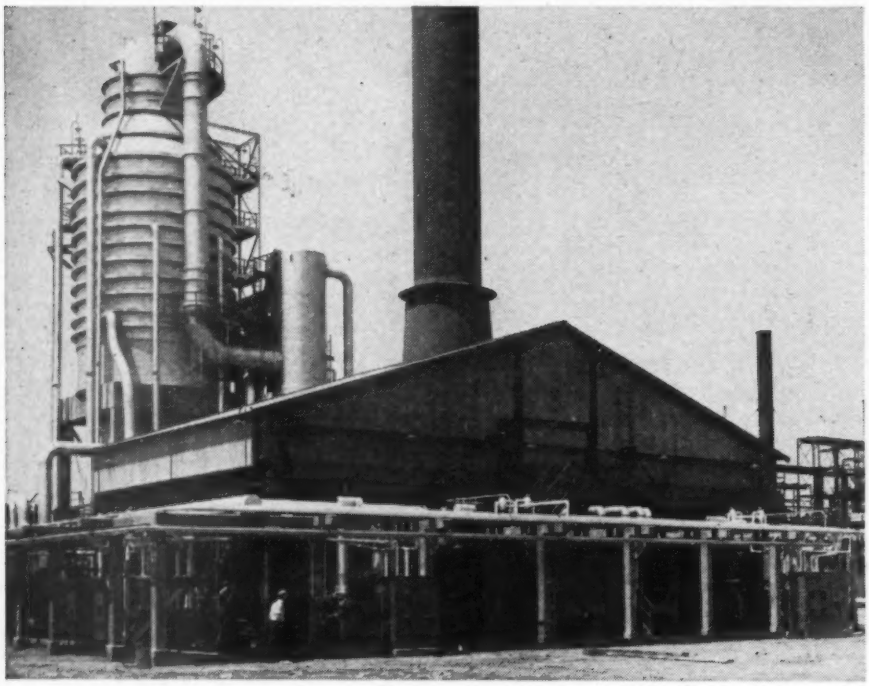
Top pumparound reflux and product vapors are condensed in the top section of the tower, which is 17 ft. in diameter. This section contains three double-pass plates and a drawoff pan with vapor risers.

Liquid from the flash zone runs down into the stripping section, 18 ft. in diameter, which contains six bubble cap plates. Superheated exhaust steam, introduced into the lower bottom, contacts the descending liquid stream stripping out the last traces of gas oil. To minimize the tendency of the pitch bottoms to crack when held at high temperatures for extended periods of time, the accumulator section has been provided with a very low liquid holdup.

The caps and trays are of lightweight alloy construction. The tower shell is carbon steel. The stripping and flash zone sections have walls ⅜-in. and ½-in. respectively. In ad-



As seen from the top of neighboring atmospheric pipe still, the picture at the right of Esso's new vacuum pipe still shows the huge feed surge drum in front of the main fractionating tower



Furnace for new pipe still is standard SOD double end-fired box type. Occupying a space 45 x 80 ft., it is designed to fire 180 million Btu./hr. It has a common center convection and two radiant sections

dition, both of these sections are clad with a ⅛-in. layer of 18-8. The pumparound sections are unclad and have been provided with ¼-in. corrosion allowance. The wall thickness of the bottom pumparound section is ⅜-in. and of the top pumparound section 11/16-in.

To raise the temperature of the feed stock requires a furnace designed to fire 180 million Btu's per hour, and occupying a space 80 x 45 ft. This heater is a standard SOD double end-fired box type furnace. Often referred to as a double wing type, it is characterized by a common center convection section and two radiant sections. The bridge wall and stack are self-supporting. Oil flow through the furnace is through four separate parallel circuits with the tubes in each circuit arranged for series flow. At the center of each radiant section the parallel circuits are combined so that two 14-in. alloy transfer lines take the heated oil charge to the tower.

To transfer the heat to oil and steam requires 17,500 sq. ft. of surface provided by 292 six-inch O.D. tubes. Tubes in oil service are 4-6 chrome with ⅜-in. wall. Exhaust steam for stripping is superheated in carbon steel tubes 6-in. O.D. by ¼-in. wall. The superheater is piped for parallel flow to keep the pressure drop low.

Each radiant section is equipped with 16 tandem-type burners for either 100% oil or gas firing. Twelve burners are installed in each front-wall, firing at right angles to the tubes. Two burners have been provided in each sidewall for firing flexibility. The outlet of each oil circuit has been provided with a temperature indicator and recorder. Automatic controls have been installed on the combined coil outlets so that firing to each radiant box is automatically controlled. The control is cascade type with a temperature recording controller resetting a flow recording controller to vary the firing rate. Oil and gas firing controls are arranged through an air selector switch so that when firing automatically with gas it is possible to trim with oil under manual control. The reverse control is also possible.

Two brick buildings, a switch house and a control house, have been provided. The switch house is 25 x 15 ft. and houses the 440-volt switch gear. The house is pressured to ⅛-in of water to reduce explosion hazards. Sufficient space has been provided in the 60 x 23 ft. control house for the installation of a future gage board. A complete picture of operating conditions is readily afforded through level, flow, pressure, and temperature recorders and indicators.

Description of Flow

Fig. 1 illustrates the flow through the unit. Hot feed stock at a temperature of 430° F enters the unit at battery limits through a feed manifold. Feed for the unit comes from the crude distillation units and enters the feed surge drum. The drum rests on a skirt sheet and is provided with a static head type level recorder and high and low level alarms. Of the three hot feed pumps, two running in parallel are used at design rates. Feed passes through the tube side of the bottom pumparound to feed exchangers in two parallel streams passing through five exchangers in series in each bank. The feed temperature is raised to 520° F in picking up 39,000,000 Btu/hr. A similar parallel flow split is made at the bottoms-feed exchangers with four exchangers in series in each bank.

The feed picks up 36,000,000 Etu/hr. from the bottoms and leaves the preheat train at 595° F. At the coil inlet the feed is split and passes through the furnace in four separate parallel circuits, each circuit under flow control. Before entering the tower, the temperature of the feed stock is raised to 800° F. About 43% of the total charge, representing flashed and steam-stripped vapors, rises up the tower to be condensed in the pumparound sections.

Bottom pumparound reflux, withdrawn from the tower, exchanges heat with the incoming feed and then passes through three parallel steam generators before returning to the tower under flow control. Steam generated in these shells passes to the steam drum and thence to the

TABLE 2—Major Equipment Summary

A. Vacuum Column

Section	Diam., Feet	Number of Bubble Trays
Top	17	3
Middle	27	2
Bottom	18	6
Overall Height	93	

B. Drums

Item	Diam., Feet	Height, Feet
Feed Surge Drum	10.5	50
Condensate Surge Drum	5	10
Steam Drum	5	20

C. Heat Transfer Surface

Item	Number Shells	Surface, Sq. Ft.	Duty, Btu/Hr.
Exchangers	22	44,260	114,000,000
Coolers	6	11,280	85,000,000

D. Fired Heater

Section	Surface, Sq. Ft.	Material
Radiant	7,440	4-6 Chrome
Convection	10,000	4-6 Chrome & Carbon Steel
Heat Fired	180,000,000 Btu/Hr.	
Heat to Oil & Steam	120,000,000 Btu/Hr.	

refinery steam main. The quantity of head removed in the bottom pumparound circuit can be varied by changing the flow rate; a back pressure controller on the steam drum can also be used to vary the rate of heat removal. Preheated treated feed water for the steam generator is pumped to the steam drum under level control. Continuous blowdown is provided for the steam drum.

Top pumparound product is taken off the discharge of the top pumparound product and reflux pump under level control. A separate bottom pumparound product pump sends bottom pumparound product under level control to a junction with the top pumparound product. The total gas oil product stream can then be cooled and sent to storage or can bypass the coolers and be pumped to the new fluid catalytic cracking unit as hot feed stock.

Steam and a trace of oil vapors from the column pass through a 48-in. overhead line to a barometric condenser. The overhead line weighs nine tons and is provided with an expansion joint to take the differential expansion between the tower and condenser. Noncondensable gases from the barometric condenser are evacuated through three sets of two-stage jets. Normal operation will be with two sets running. Motive steam for the first-stage jets is condensed in an intercondenser. Final compression of the gases occurs in the second-stage jets. Steam from these jets is discharged through tail pipes to the sump pit. The effluent from the sump pit passes offsite to a separator where any oil carried over is recovered.

Bottoms from the unit exchange heat with the incoming feed before leaving the vacuum still area for further processing.

Training

The operators for this particular unit underwent an intensive training preparatory program. Novel in this training course was the use of a small table model representing the vacuum pipe still equipment. To represent the piping and in order to familiarize the operators with the layout, colored wires representing the various oil and utility circuits were equipped with jack plugs. By repeated dis-assembly and re-assembly, the operators thus became familiar with the piping and equipment layout.

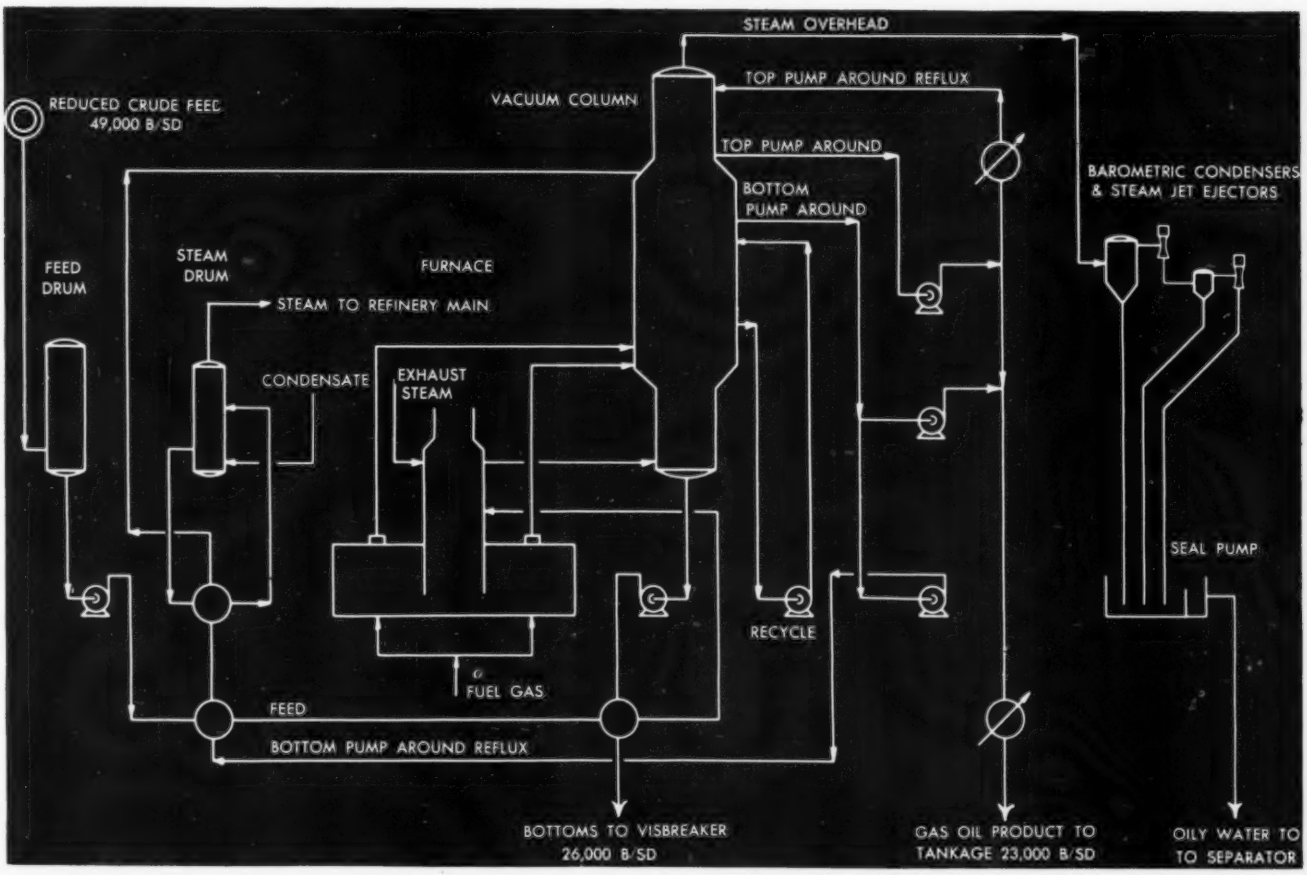
Initial Operations

Prior to introduction of reduced crude, a vacuum test was run on the system. Excessive leakage was traced to the flange on the 30-inch barometric condenser tail leg. Refinery forces tightened the flange and provided auxiliary support for the tail leg. This and other major leaks were detected primarily by ear and by feel. When a satisfactory vacuum test had been completed, light oil was circulated to clear circuits and bring up temperatures. During light oil circulation most of the control instruments were checked for satisfactory operation.

Shortly after startup, one atmospheric pipe still was charging West Texas crude. Due to thermal decomposition of organic sulfur compounds at the elevated temperatures, evolution of H_2S at the sump and to a lesser extent at the feed surge drum became obnoxious. Facilities were provided to collect the evolved gases from the sump and the feed surge drum and to burn the vapors in an inspirating type burner obtained for this purpose and installed in the furnace.

The unit has now been on stream for five months since the initial firing-up. The operation has been satisfactory under a wide variety of operating conditions, including the processing of residua not contemplated in the original design. A test program is currently under way to determine the effects of the several variables on utility consumption and product distribution to allow optimum operation of the vacuum pipe still in the integrated refinery processing system.

Fig. 1 — Simplified flow diagram of Esso's new 49,000 b/d vacuum pipe still recently placed on stream at Bayway



Unusual Processing Arrangements Used In New Carthage Gasoline Plant

THE largest gas processing plant so far built for delivery of dry natural gas to gas pipe lines has been completed near Carthage, Texas, for the Carthage Corp. of Shreveport, with Hudson Engineering Corp. as engineer-contractor. Although processing some condensate, the new installation is not a cycling or pressure-maintenance operation.

The Carthage plant is connected to 167 wells, drains 73,800 acres of gas-producing horizons ranging from 4900 to 6100 ft. deep and has a design throughput of approximately 385,000 Mcf. per day. Several patent applications are pending and cover some of the processing, appearing here for the first time in a commercial installation.

Several Features of Interest

Among the features of particular interest are:

1—A new continuous dehydration process featuring the use of a liquid desiccant of undisclosed composition to produce a very low dew point in the residue gas.

2—A unique design for the still, utilizing a Raschig-ring packed section designed for vapor load but capable of handling a far greater liquid volume than permissible for conventional trays in a column of equal diameter.

3—Designed to produce solvent naphthas, kerosine, mineral seal oil and residuum, in addition to finished motor fuel and stabilized grades of "natural gasoline."

4—One of the first if not the first to use Dowtherm as a process heating medium for precise temperature control.

5—Designed for future conversion to manufacture close-boiling solvents with a minimum of additional process equipment.

Gas Processing Section

The mixed gas and condensate comes to the plant from as far as 11.5 miles away. The hydrocarbon liquid resulting from retrograde condensation while traversing the gathering system is not separated in the field; this is accomplished in the plant inlet scrubbers. Operating pressure for these scrubbers and also absorbers, dehydrators and related equipment is determined by the pressures required by the gas pipe lines served, ranging from 850 to 1250 psig.

Seven high pressure bubble-tray absorbers, 66 in. I.D. by 72 ft. high, are required. Absorption oil is supplied by a 6-stage centrifugal pump, supply for the 850 psi. absorber being taken from the fourth stage. Rich oil from the absorbers flows through two flash tanks in series and thence to a surge tank, where a third flash occurs. Vapors from the first two flashes are returned to the absorbers after recompressing, while those from the third (rich oil surge) are reabsorbed.

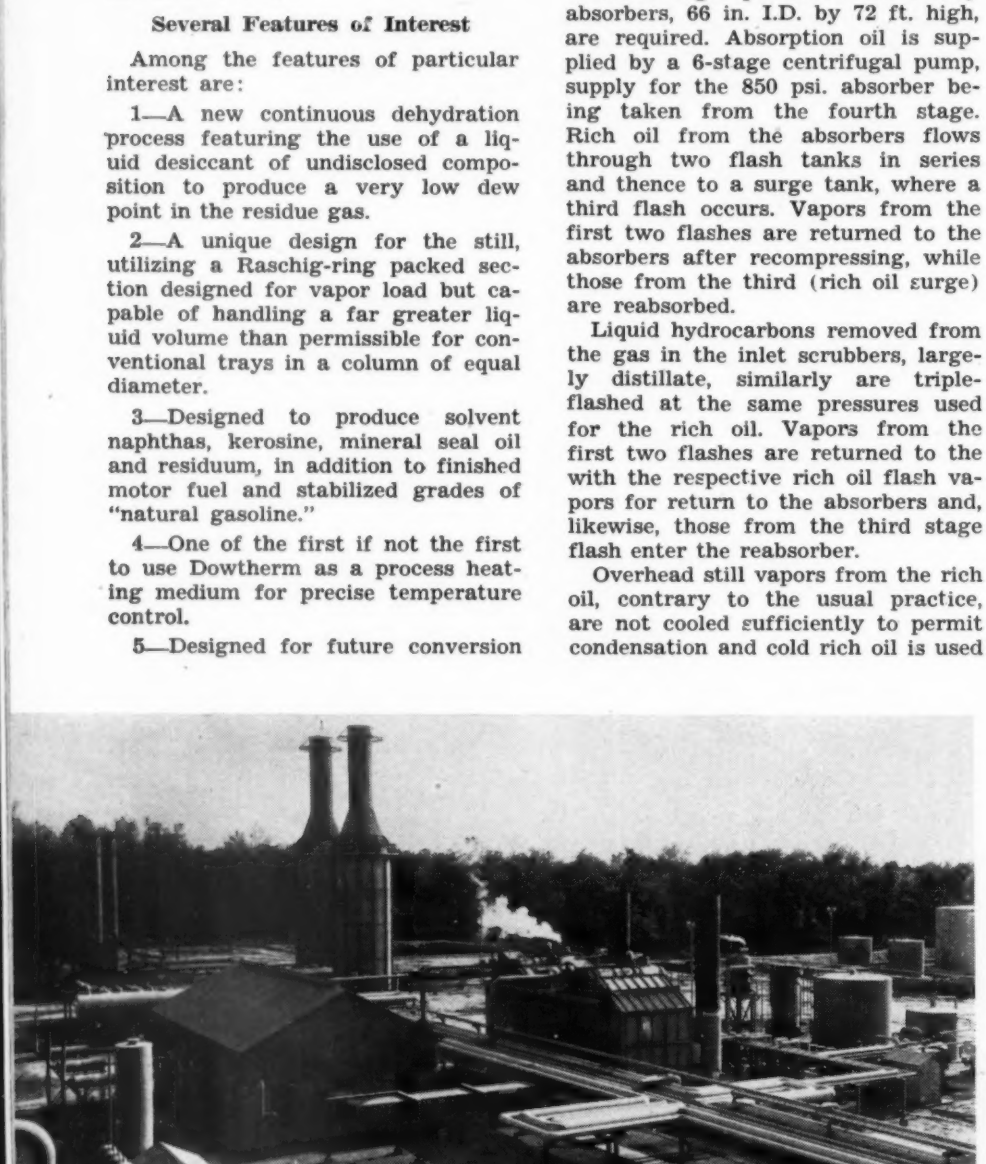
Liquid hydrocarbons removed from the gas in the inlet scrubbers, largely distillate, similarly are triple-flashed at the same pressures used for the rich oil. Vapors from the first two flashes are returned to the with the respective rich oil flash vapors for return to the absorbers and, likewise, those from the third stage flash enter the reabsorber.

Overhead still vapors from the rich oil, contrary to the usual practice, are not cooled sufficiently to permit condensation and cold rich oil is used for reflux. Instead, they enter the bottom of a "Distillate Propanizer-De-ethanizer" column, flowing upwards countercurrent to the distillate stream coming off the last stage of distillate liquid flash described in the preceding paragraph. This distillate consists primarily of comparatively heavy hydrocarbons at a relatively low temperature and serves as an excellent absorbent for the desired recovery of propane and butanes. It also already is saturated with methane and ethane and consequently rejects the bulk of these hydrocarbons not discarded in previous operations.

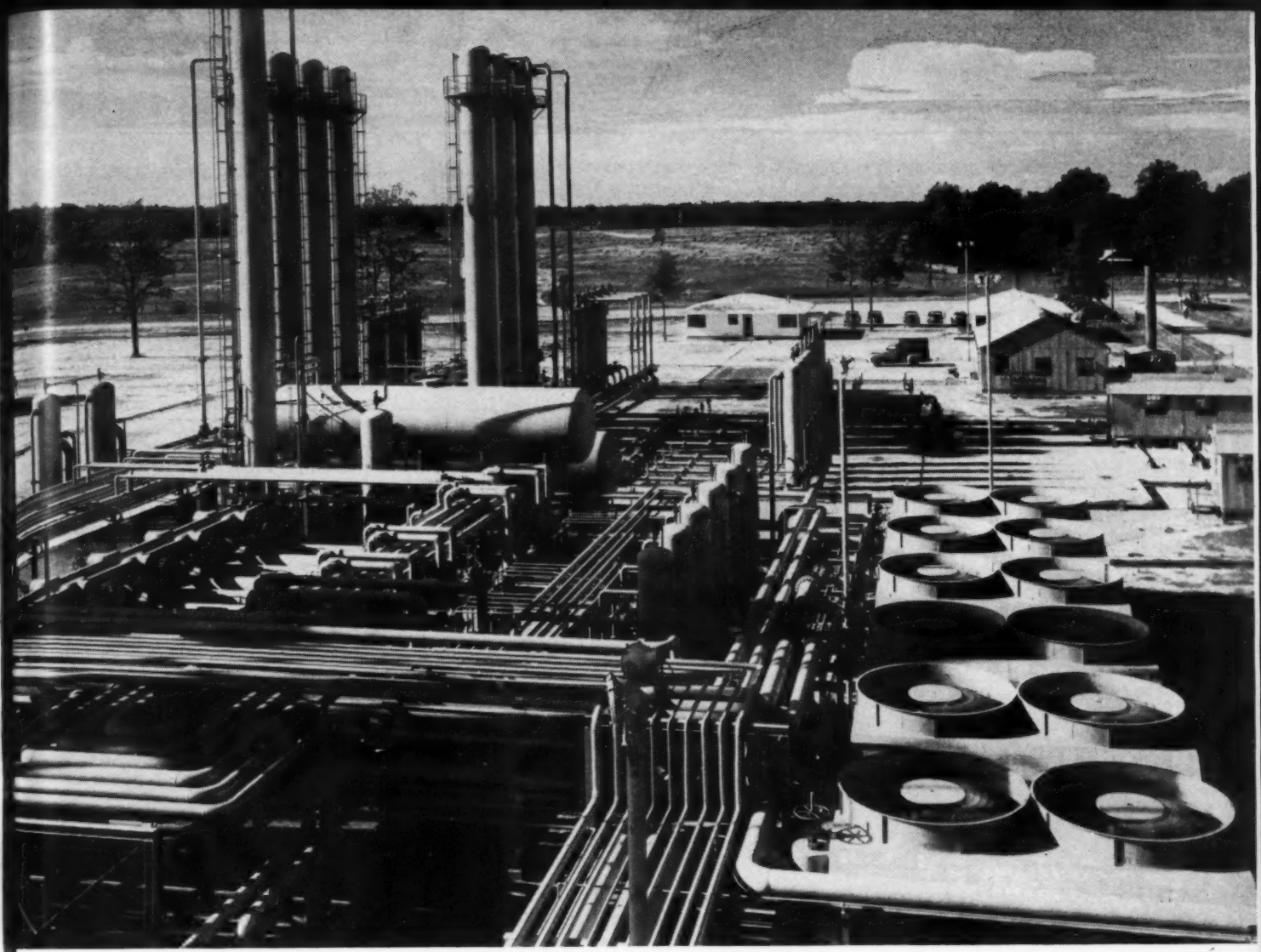
The distillate is combined in the lower part of the Distillate Propanizer-De-ethanizer with condensed hydrocarbons from the still overhead and the entire liquid stream stripped with vapors generated in the reboiler connected to the column. Effluent reboiler liquids under level control comprise the entire plant production. Vapors leaving the top of the column are less in volume than the uncondensed still overhead vapors, yet the liquid leaving the reboiler is stripped of ethane and lighter to final product specifications. Reboiler heat is from low-pressure exhaust steam and also serves to preheat debutanizer feed.

Additional recovery of desirable hydrocarbons and rejection of C_2 and lighter is secured by passing overhead vapors from the Distillate Propanizer-De-ethanizer into the rich oil surge tank feeding the still. The near-equilibrium between rich oil and vapors so obtained accomplishes the dual purpose of absorbing heavier hydrocarbons carried into the vapor and stripping lighter hydrocarbons from the rich oil. The volume of uncondensed vapors leaving the surge tank is approximately half the volume of entering vapors, yet methane in the rich oil effluent is considerably less than in the rich oil entering the tank.

The still, not heretofore described in detail, is of particular interest because of the use of a Raschig-ring packed section. The still operation is conventional in that the flashed rich oil goes through the usual preheat train into a separator, vapors from which pass directly to the still while



Plant utilities at the Carthage plant are shown in this view of the direct-fired heaters and steam boilers. Part of the storage is visible at right



General view of processing area at recently-completed Carthage Corp. gas processing plant, showing the seven main absorbers, part of the maze of process piping and air-cooling facilities

the liquid first passes through direct fired heaters before entering; the stripping medium is steam. However, to conserve heat and reduce the load on heaters and condensers, cold rich oil is used as the reflux medium.

The volume of liquid handled in the stripping section far exceeds the generally accepted safe liquid loading for trays in a column designed conservatively for the vapor load. Instead of increasing column diameter sufficiently to accommodate the liquid load with standard design trays, a unique design on which patents are pending is employed, using Raschig rings. This packed section, of a diameter selected for vapor load, has operated with a stripping efficiency equal to that of a bubble-tray column of equal height and greater diameter.

Product Fractionation

The fractionation system may be divided into light and heavy ends fractionation, of which the former consists of debutanizing with the depropanizer taking feed on debutanizer overhead to make the split between propane and butanes. Debutanizer bottoms of controlled vapor pressure are charged to the heavy product fractionator battery.

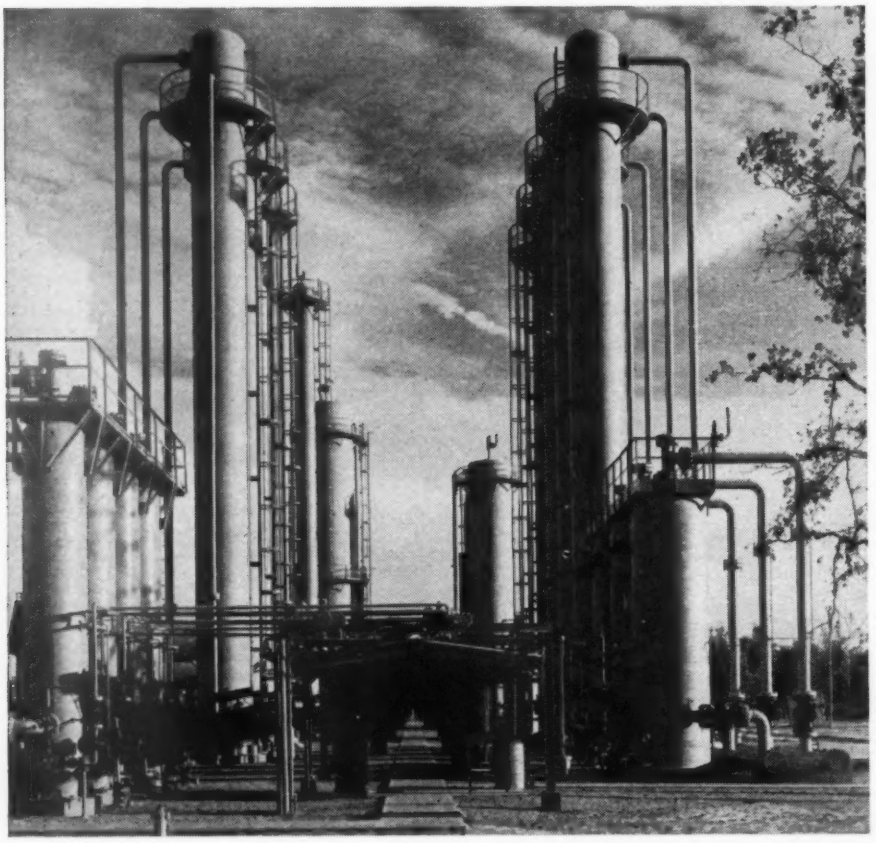
Four heavy product fractionators ordinarily are not found in plants operating on distillate and these units in particular are unusual because they are reboiled with Dowtherm vapor. The first column in this battery is the gasoline fractionator, designed to take controlled end point gasoline overhead. Next is the naphtha fractionator, producing a controlled end point naphtha overhead.

Naphtha column bottoms are split into a kerosine product overhead in the third column, while the fourth makes a mineral seal oil overhead cut and residuum bottoms. Each of the four heavy product fractionators already is equipped with side-draws. Thus, with the addition of strippers and associated equipment, the plant will be able to produce a variety of special solvent naphthas and other narrow-boiling fractions as future markets dictate—and at a minimum of revamping expense.

Dowtherm "A" vapor is condensed in the reboilers of these last four columns, heat input being controlled by the appropriate instruments. This unusual feature for natural gasoline plants was selected because it was desired to make a wide variety of heavy product fractions to close specifications, requiring higher temperatures than normally achieved with steam as the heating medium. At the same time, precise control, wide temperature ranges and great flexibility were very desirable.

The Dowtherm unit at the Carthage plant is large by comparison with other Dowtherm installations. It consists essentially of two vaporizers, four "users" (which are the column reboilers), a surge tank and the charge pumps. The reboilers operate at different temperatures, from 450 to 600° F. The vaporizers generate vapor at 650° F. To date Dowtherm losses have been exceedingly small and process temperature control is precise and uniform.

Another of the unusual features in this plant is the use of a new liquid desiccant process to dehydrate gas for pipeline delivery. Called the "Dessiflo" process, and the liquid, "Dessico," the operation is continuous and capable of producing low dew points. Pressures maintained in the several contactors are set by gas pipe line delivery requirements. A single regenerator is used. Copyrights have been applied for on the name and patents on the process. At Carthage the water content of the gas must be below 7 lbs. per 1000 Mcf. to meet



This unusual "liquid hydrocarbon boulevard" shows the heart of the Carthage plant framing the central operating promenade. At left and right foreground are gas scrubbers with absorbers behind; large vessels in background are the still and "distillate propanizer-de-ethanizer" columns

gas sales contracts and the dehydrating plant was designed to dry 110° F. gas to meet this requirement. The Dessiflo unit has exceeded design specifications, reducing the water content to less than 4 lbs. per 1000 Mcf.

Cooling Facilities

Water is available from wells near the plant in limited quantity only, and contains a high concentration of dissolved salts particularly rich in iron and silica. Extensive treating is required to secure suitable cooling and boiler feed water. Therefore, it was necessary to reduce water consumption to the minimum, and particularly important to avoid using this water in high temperature cooling and condensing services, where high skin temperatures would be unavoidable, to eliminate scaling. This latter consideration made the use of air-cooling advisable for these services.

Hudson-type air cooled exchangers containing multiple horizontal rows of finned tubes are used, with induced draft fans electrically driven through speed reducing gears. These are used in the following services: still overhead vapor primary condenser, debutanizer overhead vapor condenser, motor gasoline vapor condenser, naphtha condenser, kerosine condenser, mineral seal oil condenser, residuum cooler, and exhaust steam condenser.

All other cooling services are handled by water. The cooling tower is a Hudson induced draft type, having a coil shed base accommodating atmospheric type coolers and condensers. By this means lower final temperatures are obtained than would be practical with the air-cooled units.

Plant Utilities

Two steam boilers are installed, either of which is sufficient for plant steam requirements. Steam is generated at 600 psig. and superheated to 750° F. The high pressure steam supplies three prime users: raw water pump turbine, debutanizer reboiler, and high pressure absorption oil pump turbine. This latter unit, exhausting at 170 psig., provides stripping steam for the still and drives all other turbines in the plant. These, in turn, exhaust into a low pressure system which provides heat to the depropanizer reboiler, "Dessiflo" reactivator reboiler, Distillate Propanizer-De-ethanizer reboiler, debutanizer preheater and the evaporator, which provides boiler feedwater makeup. All steam is condensed, filtered to remove oil, deaerated and returned to the boilers.

Storage for propane, butanes, LP-Gas, motor fuel, naphtha, kerosine, mineral seal oil and residuum is provided at the plant site. The lead-blending plant and additional storage facilities for leaded gasoline are located near the railroad loading rack approximately 5 miles from the plant, with pipe lines provided for product transfer to these points. Truck loading racks are at the plant site on U. S. Highway 79. In addition to these facilities the plant is connected with three pumping stations which transfer products to three pipe lines terminating at Gulf Coast and Mississippi River terminals.

Control panels are outside under protective roof; each process unit has its own panel adjacent

Pressurized Still Gives Comparable Data In Crude Oil Analyses at any Altitude

USE of a pressurized receiver in place of the conventional receiving tubes in an open rack has made possible the analytical distillation of crude oils under an artificial pressure of 760 mm. Hg. This apparatus, developed by the Bureau of Mines in cooperation with the University of Wyoming at the Laramie, Wyo., experiment station, enables routine analyses of crude oil to be made in laboratories at high altitudes, with results comparable to those obtained at sea level.

This is especially important for work in the Rocky Mountain region, where barometric pressures of approximately 600 mm. Hg are encountered. For example, laboratories at 7200 ft. generally report 2 to 4% more gasoline (based on crude) than sea level laboratories, it is said.

The pressurized apparatus is shown in the schematic drawing in Fig. 1. Pressure is controlled automatically at 760 ±1 mm. by an aneroid manostat, and is indicated by a mercury manometer.

The pressurized receiver consists of a heavy glass jar, 8½ in. inside diameter and 10 in. high, clamped between a lid and base plate with eight equally spaced bolts running the entire height of the assembly. The lid and base plate were constructed of copper (suitable brass sheets were not available) ⅛ in. thick, with a ⅛-in. soft rubber gasket at the top of the jar and a ⅛-in. soft rubber cushion between the bottom and the base plate.

The jar contains a large receiving-tube rack that accommodates sixteen 30-ml. test tubes, and was designed so that chopped ice may be packed inside the circle of tubes without interfering with the rotation of the rack. Close spacing of the tubes prevents large pieces of ice from falling out and wedging between the tubes and the wall of the jar. The four large holes in the center of the top disk permit easy addition of the ice. A 2½-in. space at the bottom allows room for accumulation of water from the melting ice.

The center shaft extends through a packing gland on the lid and has a knurled knob on top for rotating the rack. A tongue-and-groove joint in the shaft just before it enters the packing gland permits the removal of the lid without disturbing the rack. The bottom of the shaft rests on a large copper bearing on the bottom of the jar.

The lid contains three tapered sleeves, one to fit a No. 4 rubber stopper and two to fit No. 8 rubber stoppers. The delivery tube from the condenser projects into the receiver through the No. 4 stopper directly above the receiving tubes. One of the large sleeves is directly above the tubes and directly opposite the small sleeve for the purpose of removing and replacing the receiving tubes. Another large sleeve is near the center of the lid, so that ice may be admitted without falling into the tubes. The corresponding holes in the upper plate of the rack permit distribution of the ice.

In operation, each stopper is secured by clamping into position with four bolts and wing nuts on a copper disk. If a clamp is used for holding the thermometer in the flask, as shown in Fig. 1, a rubber cushion must be placed underneath the lip of the flask to prevent breakage due to the pressure of the clamp. The thermometer may be tied down with 16 or 18-gage copper wire instead of clamping.

A copper ring was soldered to the upper end of the condenser, so that a clamp could be employed to secure the delivery tube from the flask. The pores in the cork stoppers must be sealed with a substance which will not readily wash back into the Hempel flask. Silicone stopcock lubricants were found unsatisfactory, because a slight amount washes back into the flask and causes extreme frothing of the oil. Among the substances used successfully were shellac, litharge and glycerine, and a thick paste made by mixing a heavy grease and graphite.

The pressurized apparatus has been used successfully for more than two years at the Mines Bureau's Petroleum and Oil-Shale Experiment

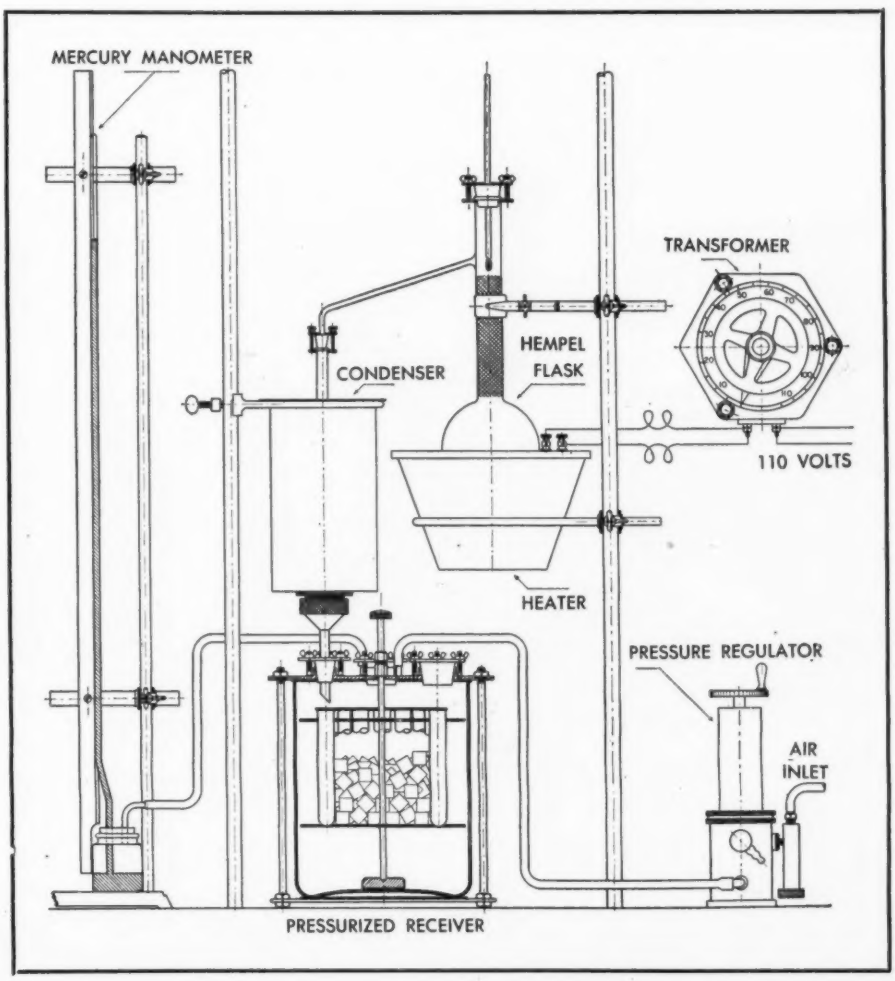


Fig. 1—Schematic drawing of the high altitude distillation apparatus

Station at Laramie, where the barometric pressure is less than 600 mm. Hg. Operation of the apparatus is only slightly more difficult than operation at atmospheric pressure, it is stated. No unusual problems have been encountered in practice.

An analysis made with the pressurized apparatus is compared in Table 1 with an analysis made on the same crude oil at the Bartlesville Petroleum Experiment Station. The table shows only volume percentages and specific gravities from Stage 1 of the routine method.

Bureau engineers have found that high altitudes have considerable effect on the results from routine analyses. For instance, the boiling points of petroleum fractions in the gasoline boiling range are decreased 14 to 20° F. when distilled at 7200 ft. elevation (pressure of 580 mm. Hg) instead of at sea level. As the gasoline content listed in the summary of a crude oil analysis is based on an end point of 392° F., the effect of a distillation at a pressure of 580 mm. Hg. is to increase the boiling range by about 20° F., and thus increase the percentage of gasoline reported by several percent of the crude, or as high as 30% of total gasoline.

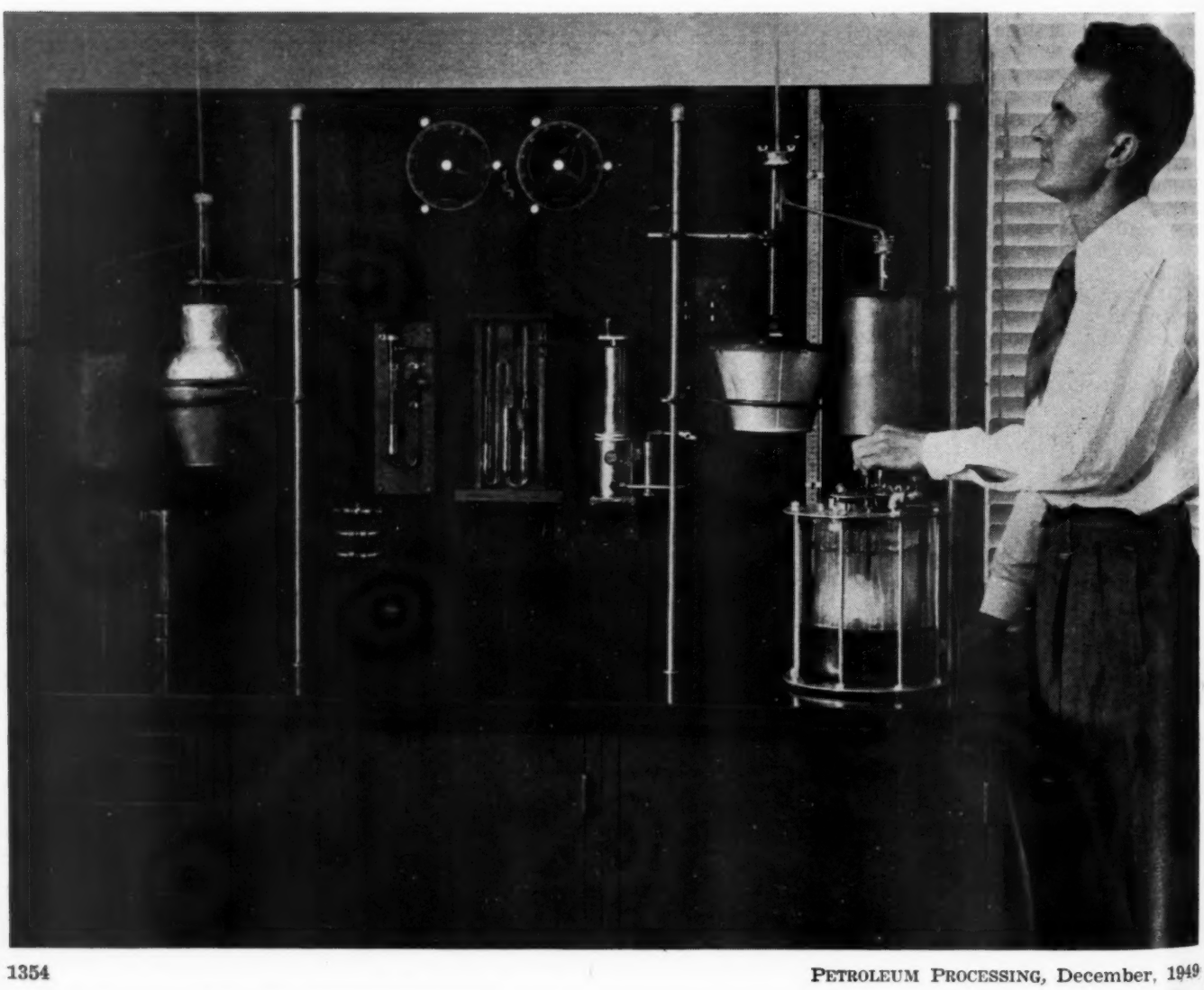
TABLE 1—Comparison of Results of Crude Oil Analyses
(Rangely, Colo. Oil—Weber Formation)

	In pressurized apparatus, 760 mm.			—At atmos. pressure, 743 mm.—		
		Accum.			Accum.	
Fraction	Vol.-%	Vol.-%	Sp. Gr.	Vol.-%	Vol.-%	Sp. Gr.
1	1.1	1.1	0.641	2.1	2.1	0.636
2	2.3	3.4	.662	2.3	4.4	.663
3	3.5	6.9	.669	3.6	8.0	.705
4	4.9	11.8	.728	4.5	12.5	.730
5	5.4	17.2	.752	4.8	17.3	.750
6	4.3	21.5	.772	4.7	22.0	.771
7	4.3	25.8	.787	4.3	26.3	.787
8	5.1	30.9	.802	5.0	31.3	.805
9	5.8	36.7	.822	6.0	37.3	.820
10	7.7	44.4	.840	7.1	44.4	.830

The kerosene boiling range also is shifted upward, and although the volume collected between 392 and 525° F. may not be greatly affected, the gravity limitation may exclude some of the higher-boiling fractions within the range and thus decrease the volume reported as kerosene.

The gas-oil content is low to the extent that the gasoline and kerosene are high, as the gas-oil end point occurs in the vacuum distillation stage, where atmospheric pressure has no effect.

The apparatus is described in detail and results of a test program are presented in the Bureau of Mines Report of Investigations 4517, "Analytical Distillation of Crude Oils at High Altitudes by the Bureau of Mines Routine Method," by Welton J. Wenger and John S. Ball, the designers of the new apparatus. A free copy of this report may be obtained from the Bureau's Publications Distribution Section, 4800 Forbes St., Pittsburgh 13, Pa.



Bureau of Mines' distillation analysis equipment, showing pressurized apparatus at right and vacuum equipment at left. Operator is W. J. Wenger, petroleum chemist at Laramie, Wyo., experiment station

Vaporization Equilibrium Constant And Activity Coefficient Charts

By K. A. SMITH, University of Wisconsin*
and R. B. SMITH, Sinclair Refining Co.

Vaporization equilibrium constant and activity coefficient charts are presented and their use is described for conditions ranging up to the critical point of the sytem.

THE calculation of vapor-liquid equilibria is essential for design and process work in connection with all distillation, absorption, and similar processing equipment. It is of particular interest at high pressures to the production engineer in connection with petroleum reservoir and pipeline studies. Previously no entirely satisfactory method had been devised to allow accurate calculations of equilibrium conditions in hydrocarbon mixtures at all conditions of temperature and pressure encountered in practice. At higher pressures ordinary vaporization equilibrium charts often give deviations of 1000% or more from reality. Through the method developed by Smith and Watson,[14] it is now possible to arrive at much improved equilibrium values extending to the critical points of mixtures. This method will give average deviations of 15% or less.

The charts presented herewith fall into two categories: (1) the "Vaporization Equilibrium Constants" which give an accurate representation of vaporization equilibria at low pressures without corrections; (2) the "Activity Coefficients" which permit corrections to be made for systems at higher pressures where deviations occur. The second group of charts is used when the corrections introduced by the activity coefficients amount to more than 5% for any component. Since much vapor-liquid equilibrium work requires the use of only the first group of charts, considerable advantage lies in being able to use the simpler charts for this work while being able to rely on the same basic method for computing equilibria where large deviations would occur.

The sources of deviation of actual vapor-liquid compositions from those given by the familiar laws of Raoult and Dalton, $y_A/x_A = P_A/\pi$, are two fold. The first of these is the assumption that the components of the mixture follow the ideal gas law. This assumption breaks down above moderate pressures. Corrections for this deviation were first made in fairly simple fashion by Brown, et al.,[9, 15] and by Lewis and associates[11, 16] through the use of vaporization equilibrium constants. The second source of error in Raoult's and Dalton's laws is the assumption that the components of the mixture form ideal solutions. The deviation resulting from this assumption occurs at much higher pressures than does the gas law deviation and the vaporization equilibrium constants cannot correct for this deviation. The trend to higher pressure operations in all fields has developed a considerable need for correcting this second type of deviation, and to accomplish this it is necessary to take into account not only the components in the mixture but also the properties of the mixture as a whole. This is done by the use of activity coefficients given in the second group of charts. A more extended discussion of this situation was given previously in this journal.[5, 6]

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Basic Concepts

It has been general practice to designate the equilibrium composition by the ratio of the concentration of the component in the vapor phase to the concentration of the component in the liquid phase. Dodge[2] and Gamson & Watson[6, 8] have pointed out that such an expression which represents the actual conditions existing in the mixture is best termed "equilibrium ratio" or "vaporization ratio." The vaporization ratio may then be defined as,

$$K'_A = \frac{y_A}{x_A} \quad \ldots\ldots (1)$$

Such an expression does not readily lend itself to the necessary theoretical treatment for any sound studies for expanding the data available. An expression which is very similar to this but which is thermodynamically sound is a ratio of activities, or, effectively, thermodynamic concentrations. This expression is termed the vaporization equilibrium constant and is defined as:

$$K_A = \frac{(a_A)_v}{(a_A)_l} \quad \ldots\ldots (2)$$

By means of the introduction of activity coefficients, the vaporization equilibrium constant may be related to composition as:

$$K_A = \frac{(\phi_v)_A\, y_A}{(\phi_l)_A \gamma_A\, x_A} \quad \ldots\ldots (3)$$

Further combination with Equation 1 results in the working relation:

$$K'_A = \frac{y_A}{x_A} = \frac{(\phi_l)_A \gamma_A}{(\phi_v)_A} K_A \quad \ldots\ldots (4)$$

where,

$(\phi_v)_A$ = vapor phase activity coefficient expressing deviations from ideality resulting from differences in molecular size or volatility.

$(\phi_l)_A$ = liquid phase activity coefficient for deviations from the laws of ideal solutions in the liquid state as a result of differences in molecular size or volatility.

γ_A = activity coefficient expressing deviations from the laws of ideal solutions as a result of chemical dissimilarity in non-ideal systems.

In mixtures of hydrocarbons the coefficient γ may be neglected since these compounds constitute ideal systems although they do not follow the laws of ideal solutions. Ideal systems have been defined[5, 8] as those which tend to form ideal liquid solutions at low temperatures where the saturated vapor of each component behaves as an ideal gas.

It may be seen that the actual vaporization ratio is readily obtained from Equation 4 if the vaporization equilibrium constant and the activity coefficients can be evaluated. To facilitate this a series of charts have been set up which allow the determination of these

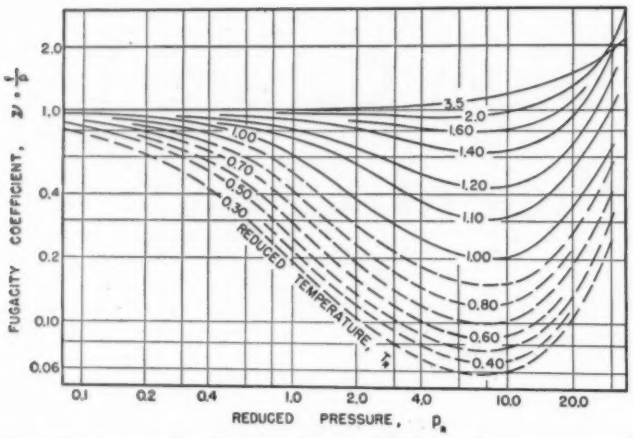

Fig. 1—Generalized fugacity coefficients for gases and vapors

factors from a knowledge of the temperature, the pressure and the composition of the mixture.

Numerous other correlations have been made which attempt to predict y/x without the use of activity coefficients.[1, 7, 9, 10, 11, 12, 13, 15] Some of these are suitable in the range of low pressures and for mixtures of narrow boiling range. However none of these is entirely satisfactory at conditions approaching the critical point of the mixture. The use of these activity coefficients allows reasonably accurate calculations to be made up to and within the retrograde region.

Vaporization Equilibrium Constants

The basic charts needed for this work are the vaporization equilibrium constant charts. These have been established on a firm and reproducible basis by replacing activities in Equation 2 with the equivalent fugacity expressions and using a chart of fugacity coefficients as a function of reduced conditions in accordance with the law of corresponding states to evaluate the expression. The following equation results:

$$K_A = \frac{\nu_s P_s e^{[v_m(\pi - P_s)]/RT}}{\nu_\pi \pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Evaluation of this expression can be made by use of the fugacity coefficient chart which is shown in Fig. 1 as extrapolated by Smith and Watson. The vapor pressure, P_s must be extrapolated beyond the critical point in this expression and this is accomplished by means of the Gamson-Watson[4, 8] equation:

$$\log P_s = \frac{-A}{T_r} + B - e^{-20\,(T_r - b)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The molal volume is obtained from the expression for the molal volume of an incompressible liquid as proposed by Gamson and Watson:[6]

$$v_m = (v_1\omega_1)\ (5.7 + 3.0\ T_r) \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

With these factors it is possible to establish a complete set of vaporization equilibrium constant charts.

These charts have been drawn up by plotting $K\pi$ as a function of temperature and pressure. Plotting $K\pi$ has the advantage of reducing the variation with pressure and resulting in a chart which is more accurate and is easier to present and to read. Such a plot results in no inconvenience, as $K\pi$ may be used directly in most calculations and as such is analogous to vapor pressure.

For materials ordinarily handled as pure components, such as the lighter hydrocarbons, it is most convenient to develop charts for the individual components plotting temperature as the abscissa and $K\pi$ as the ordinate, and using pressure as the parameter. Fig. 2 represents such a chart for methane as calculated by the above method.

Heavier hydrocarbons which are normally characterized by their boiling point are more conveniently plotted as $K\pi$ against normal boiling point at constant pressure, using system temperature as a parameter. Fig. 3 represents such a plot at an absolute pressure of 100 psi.

Under moderate conditions the activity coefficients are sufficiently close to unity to be disregarded and the $K\pi$ charts may be used directly since $K'\pi$ is approximately equal to $K\pi$. For purposes of computations it may be helpful to consider $K\pi$ as a thermodynamic vapor pressure. At equilibrium $y/x = (K\pi)/\pi$, which is analogous to the case when Raoult's and Dalton's laws hold and

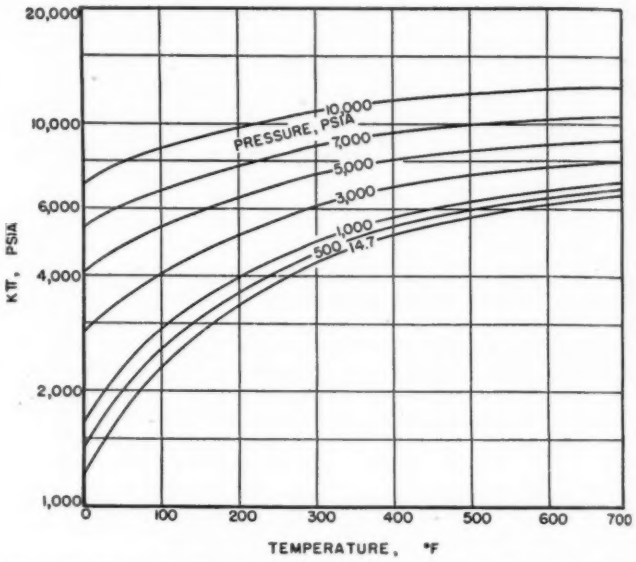

Fig. 2—Vaporization equilibrium constants for methane

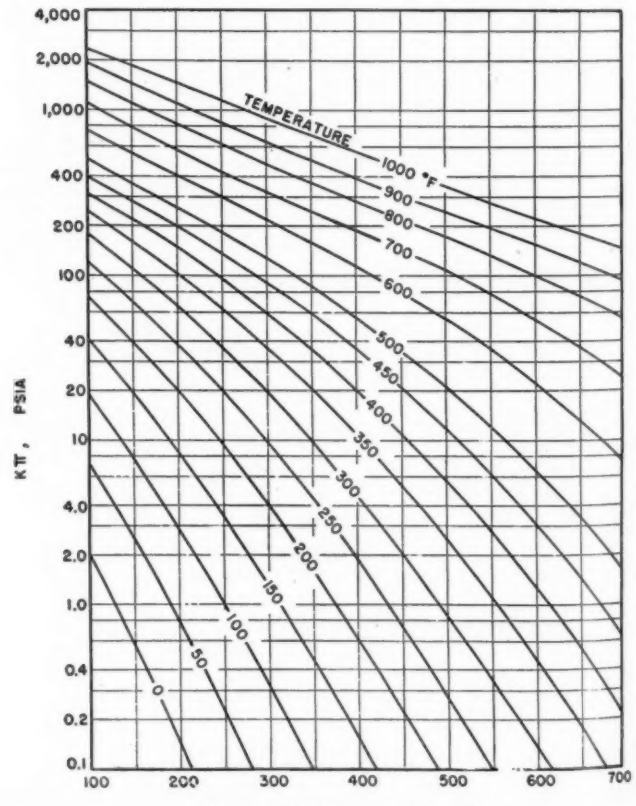

Fig. 3—Vaporization equilibrium constants for paraffin hydrocarbons at 100 psia. pressure

$y/x = P/\pi$. Therefore, the bubble point of a mixture is found when $\Sigma(K\pi)x = \pi$, and the dew point is found when $1/\Sigma[y/(K\pi)] = \pi$. At low pressures the variation of $K\pi$ with pressure is small and when solving for the equilibrium pressure trial and error computation is eliminated or reduced to a minimum. This is also true for higher pressures if a reasonable estimate of the equilibrium pressure is made.

An example of this use of the $K\pi$ charts is shown by the following bubble and dew-point computations:

Illustration 1

At what pressure will a stabilizer operate with a kettle temperature of 300° F. to produce a bottoms product of the following composition?

Component	Mol. %
n-Butane	10
n-Pentane	70
n-Hexane	20
Total	100

Solution:

		Assume π=200 psia: 300° F.		Assume π=220 psia: 300° F.	
Component	x	$(K\pi)$	$(K\pi)x$	$(K\pi)$	$(K\pi)x$
n-Butane	0.10	365	36.5	372	37.2
n-Pentane	0.70	214	149.8	222	155.4
n-Hexane	0.20	127	25.4	137	27.4
Total	1.00		211.7		220.0
			200 psia is low.		220 psia is correct.

The stabilizer will operate at 220 psia.

Illustration 2

What pressure is required on a stabilizer partial condenser when the temperature is 133° F. and the distillate is in the vapor phase having the following composition? What is the composition of the reflux?

Component	Mol. %
Propane	15.0
n-Butane	45.0
n-Pentane	40.0
Total	100.0

Solution:

		Assume π=14.7 psia 133° F.		Assume π=50 psia 133° F.		Reflux
Component	y	$(K\pi)$	$y/(K\pi)$	$(K\pi)$	$y/(K\pi)$	$x=\pi[y/(K\pi)]$
Propane	0.150	206	0.00073	215	0.00070	0.035
n-Butane	0.450	74	0.00608	78	0.00577	0.288
n-Pentane	0.400	26.7	0.01498	29.5	0.01357	0.677
Total	1.000		0.02179		0.02004	1.000
		$\pi = 1/\Sigma[y/(K\pi)]$ = 1/0.02179 = 45.9 psia 14.7 psia is low.		π = 1/0.02004 = 49.9 psia 50 psia is correct.		

The pressure required on the condenser is 50 psia.

In Illustration 1 the first assumed pressure is close to the correct pressure, and the second trial is correct, as would be expected. In Illustration 2, however, the first assumed pressure is far from the correct pressure. Nevertheless, the results of the first trial indicate the correct pressure sufficiently well so that only one more trial is needed. This direct indication of the total pressure is one of the advantages of using $K\pi$.

Activity Coefficients

Charts for the vapor phase and liquid phase activity coefficients were developed by Smith and Watson[14] and when used in conjunction with the $K\pi$ charts result in improved values for equilibrium calculations, particularly at high pressures. The coefficient for the vapor phase, ϕ_v, has been correlated at constant values of the pseudo reduced pressure of the vapor phase at convenient intervals up to a reduced pressure of 10.0. Fig. 4 illustrates a typical vapor phase activity coefficient chart. Logarithmic interpolation between such charts results in satisfactory coverage of the pressure range. Pseudo reduced temperature has been used as the parameter on the charts, and the correlating variable is the ratio of the critical temperature of the component in question to the pseudo critical temperature of the vapor phase. Thus, from a knowledge of the temperature, the pressure and the composition of the vapor phase, the activity coefficient for each component in the phase may be determined. The coefficients are not dependent on the properties of the other phase present. The use of these charts is best shown by means of an illustration.

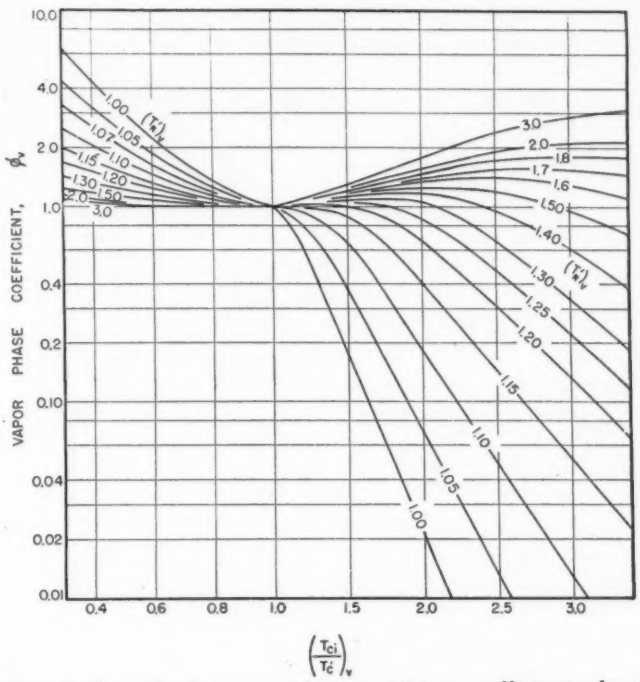

Fig. 4—A typical vapor phase activity coefficient chart

Illustration 3

By the use of the vapor phase activity coefficient charts, obtain the value of ϕ_v for each of the components present in a vapor of the indicated composition at 220° F. and 1000 psia.

Component	Mol. %
Methane	43.6
Propane	42.0
n-Pentane	14.4
Total	100.0

Solution:

The pseudo-critical properties of the mixture are calculated as a molal average and from these the variables on the charts are determined.

Component	y	T_{ci}, °R	$\Sigma(y_i T_{ci})$	p_{ci}, psia	$\Sigma(y_i p_{ci})$	$\left(\frac{T_{ci}}{T_c'}\right)_v$
C_1	0.436	344	150	673	293	0.62
C_3	0.420	666	280	617	259	1.21
n-C_5	0.144	847	122	485	70	1.53
	1.000		$552=(T_c')_v$		$622=(p_c')_v$	

$$(T_r')_v = \frac{T}{(T_c')_v} = \frac{680}{552} = 1.23$$

$$(p_r')_v = \frac{p}{(p_c')_v} = \frac{1000}{622} = 1.61$$

Using these values and interpolating logarithmically between charts the values of ϕ_v are as follows:

Component	ϕ_v
C_1	1.23
C_3	1.03
n-C_5	1.00

Similarly, the liquid phase coefficient ϕ_l is correlated at constant values of pseudo reduced pressure using

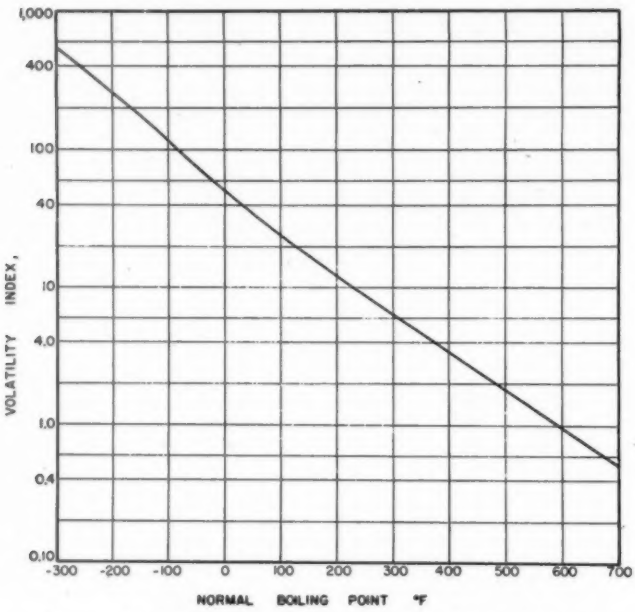

Fig. 5—Volatility index for paraffin hydrocarbons

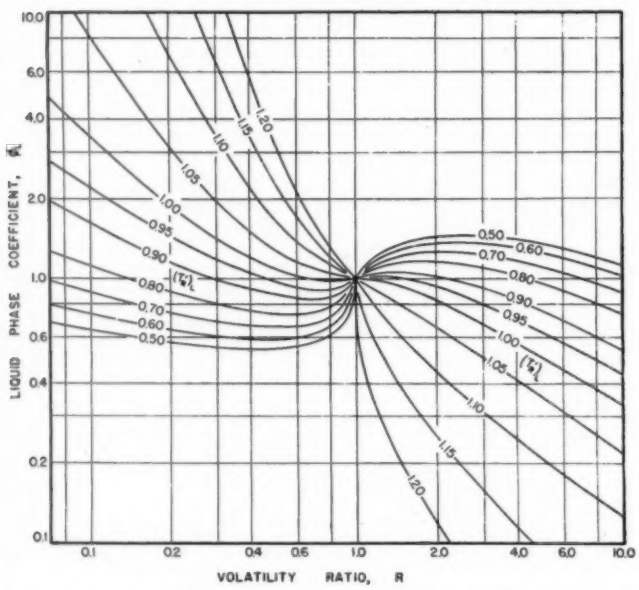

Fig. 6—A typical liquid phase activity coefficient chart

pseudo reduced temperature as the parameter, as shown in Fig. 6. In this case, however, the correlating variable is the volatility ratio, R, which was devised for this work. Values of the volatility index, r, are given in Table 1 for paraffin hydrocarbons and also are plotted as a function of normal boiling point in Fig. 5. The volatility ratio is then defined from the volatility index of the components present as follows.

For the lightest component:

$$R_L = \frac{r_L}{\Sigma(x_i r_i)} \quad \ldots\ldots (8)$$

For the heaviest component:

$$R_H = \left[\Sigma\left(x_i \frac{1}{r_i}\right)\right] r_H \quad \ldots\ldots (9)$$

Intermediate components in multicomponent systems require special consideration. For these components it is usually necessary to calculate the volatility ratio by use of both Equation 8 and Equation 9. If the ratio R_H is less than 0.80, the component may be considered heavy and R_H used as the proper ratio with the correlation. If, however, R_H is greater than 0.80 an average value for the volatility ratio must be obtained. Fig. 7 has been constructed as an averaging chart for this purpose. The corresponding values of ψ from Fig. 7 are obtained for the two methods of calculating R and the arithmetic average of these values of ψ is computed. This average value is then used to obtain from the chart an average value of R, which serves as the correlating variable. This procedure is more clearly demonstrated by the following illustration:

Illustration 4

From the use of the charts, obtain the value of ϕ_i for each of the components present in a liquid of the indicated composition at 220° F. and 1000 psia.

Component	Mol. %
Methane	20.8
Propane	47.5
n-Pentane	31.7
Total	100.0

Solution:

Pseudo reduced temperature and pressure are calculated in the usual manner.

Component	x	T_c, °R	$\Sigma(x_i T_{ci})$	p_c, psia	$\Sigma(x_i p_{ci})$
C_1	0.208	344	72	673	140
C_3	0.475	666	316	617	293
n-C_5	0.317	847	268	485	154
	1.000		$656=(T_c')_l$		$587=(p_c')_l$

$$(T_r')_l = \frac{680}{656} = 1.037$$

$$(p_r')_l = \frac{1000}{587} = 1.70$$

The volatility ratios are calculated in the manner indicated by Equations 8 and 9.

Component	x	r	$\Sigma(x_i r_i)$	R_L	$1/r$	$\Sigma(x_i\, 1/r_i)$	R_H
C_1	0.208	400	83.2	3.18	0.0025	0.0005	...
C_3	0.475	73	34.7	0.58	0.0137	0.0065	1.44
n-C_5	0.317	25	7.9	...	0.040	0.0127	0.49
			125.8			0.0197	

The values of R calculated for methane and n-pentane are satisfactory. However, propane is an intermediate component since R_H is greater than 0.80 and Fig. 7 must be employed to obtain an average value for R. When $R_L = 0.58$, the corresponding value of ψ is 0.74. Likewise when $R_H = 1.44$, $\psi = 0.58$. An arithmetic average

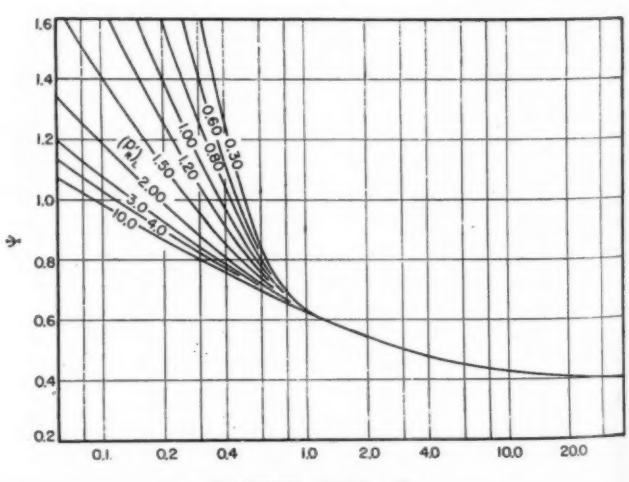

Fig. 7—Averaging chart for volatility ratios of intermediate components

of these two values results in $\psi_{avg.} = 0.66$ for which the chart indicates a corresponding value of $R_{avg.} = 0.84$. Using these volatility ratios and logarithmic interpolation between charts gives the following values for the liquid phase activity coefficients.

Component	R	ϕ_l
C_1	3.18	0.56
C_3	0.84	1.00
n-C_5	0.49	1.17

Utility of Correlations

Through the use of these charts it is possible to arrive at values for the vaporization ratio by combining the values of the activity coefficients with the values of the vaporization equilibrium constant in accordance with Equation 4. Such calculations are shown in the following illustration.

Illustration 5

The liquid and vapor described in Illustrations 3 and 4 have been reported by Dourson, Sage and Lacey[3] as being in equilibrium at the temperature and pressure indicated. Calculate the vaporization ratio and compare with the experimental data.

Solution:

Values of the vaporization equilibrium constant are read from the charts and combined with the values of ϕ_l and ϕ_v from Illustrations 3 and 4 in the form of Equation 4, assuming that γ equals unity.

Component	$(K\pi)$	ϕ_l	ϕ_v	$K'\pi = (\phi_l/\phi_v)(K\pi)$	Experimental $(y/x)\pi$
C_1	4,170	0.56	1.23	1,900	2,100
C_3	940	1.00	1.03	910	880
n-C_5	440	1.17	1.00	513	450

It will be seen that good agreement with the experimental data is obtained.

The application of the charts to the solution of an actual problem, such as a dew-point or bubble-point calculation, is very similar in nature to the usual case where activity coefficients are not used, as in Illustration 1. An additional variable is introduced because the composition of the unknown phase must be checked as well as the temperature or pressure. It has been shown[14] that these calculations are most easily made by neglecting activity coefficients to get an approximate composition and then using this composition to calculate activity coefficients. Usually about three trials are sufficient to provide a check on both temperature and composition. Partial vaporization equilibria such as encountered in flash towers may also be handled in the usual manner, again verifying the assumed composition. As a time-saving measure in making the calculations it is suggested that where a preliminary calculation ϕ_l/ϕ_v falls between 0.95 and 1.05, the ratio be assumed to be 1.0. Since this is within the accuracy of the method, it will not result in substantial errors and may often considerably simplify the calculations.

Acknowledgments

The permission of the Sinclair Refining Co. for the publication of the equilibrium vaporization constant charts is gratefully acknowledged.

The assistance of Thorpe Dresser in the preparation of these charts is appreciated.

The helpful suggestions of K. M. Watson are also gratefully acknowledged.

TABLE 1—Volatility Index for Paraffin Hydrocarbons

Compound	Volatility Index, τ	$1/\tau$
Methane	400	0.0025
Ethane	145	0.0069
Propane	73	0.0137
iso-butane	47	0.0213
n-Butane	40	0.0250
iso-pentane	27.5	0.0364
n-Pentane	25.0	0.040
n-Hexane	16.5	0.061
n-Heptane	11.5	0.087
n-Octane	8.4	0.119
n-Decane	4.9	0.204

Nomenclature

A = a constant in the Gamson-Watson vapor pressure equation.
a = activity.
B = a constant in the Gamson-Watson vapor pressure equation.
b = a constant in the Gamson-Watson vapor pressure equation.
e = the base of natural logarithms.
f = fugacity.
K = the vaporization equilibrium constant.
K' = the vaporization ratio.
P = vapor pressure.
p = pressure.
R = the gas law constant.
R = volatility ratio.
r = volatility index.
T = the absolute temperature of the system.
v = volume.
x = mole fraction in the liquid phase.
y = mole fraction in the vapor phase.
z = mole fraction in the total system.
γ = activity coefficient for the liquid phase concerning chemical type.
ν = the fugacity coefficient.
π = the total pressure of the mixture.
Σ = summation.
ϕ_l = activity coefficient for the liquid phase concerning molecular size or volatility.
ϕ_v = activity coefficient for the vapor phase.
ψ = a function for averaging volatility ratios.
ω = the liquid expansion factor.

Subscripts and Superscripts

A = component A.
avg = molal average.
c = critical property.
H = heaviest component.
i = the ith component.
L = lightest component.
l = liquid phase.
r = reduced state.
s = saturation.
v = vapor phase.
π = total pressure.
$'$ = the psuedo property (except K').

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41 Working-Scale Charts Available

A booklet containing 41 working-scale charts of vaporization equilibrium constants and activity coefficients is available. It contains a reprint of the preceding paper, 21 equilibrium constant charts for the hydrocarbons from methane to 700° F. boiling point, and 20 activity coefficient charts. A sample of the charts and a complete list of all 41 charts appears on the following page.

The booklet contains 48 pages, 8½ x 11 in., and is bound in a heavy paper cover. Copies are available for $1.50 each, postpaid. (Ohio purchasers please add 3% sales tax.) Send orders, with remittances, to

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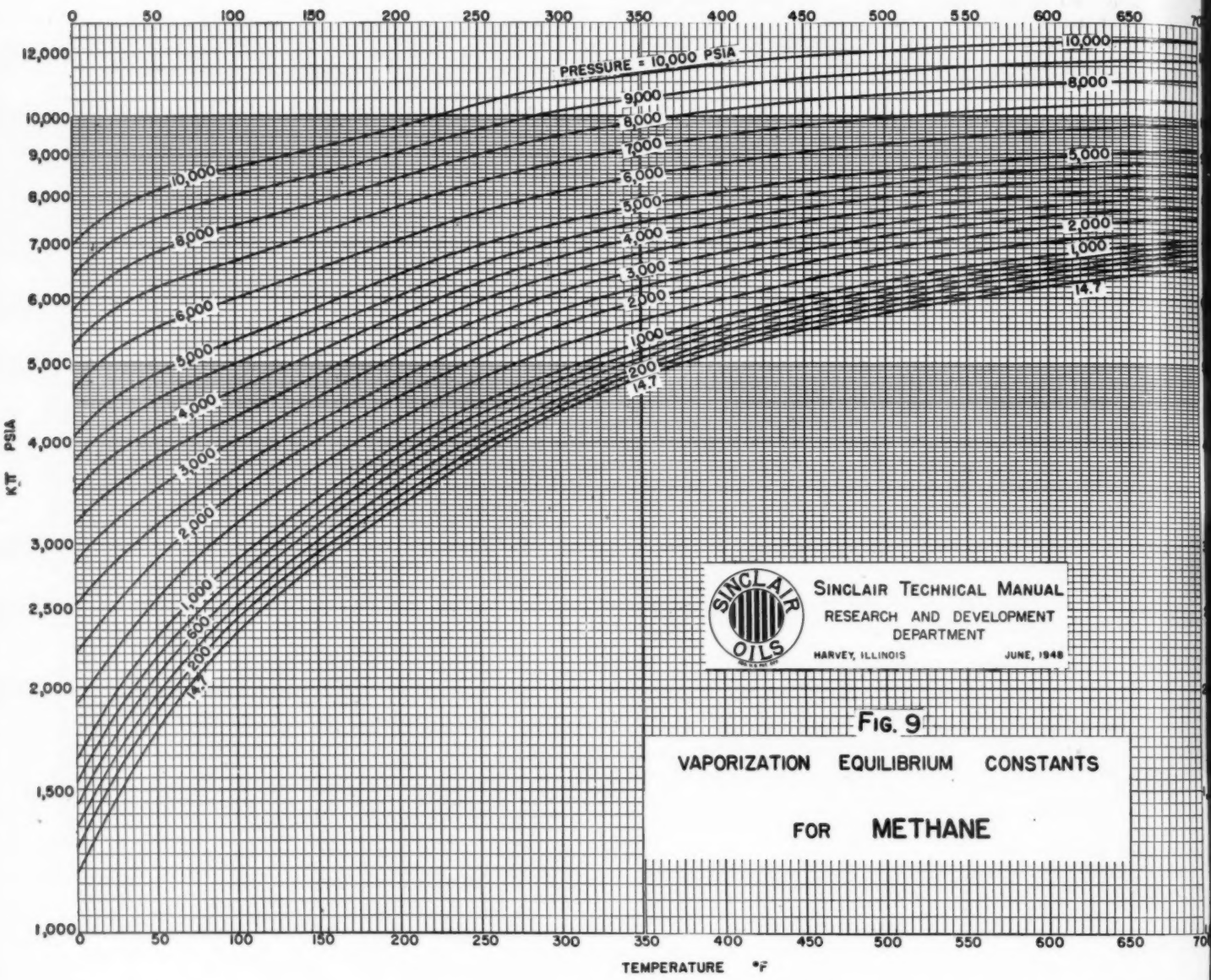
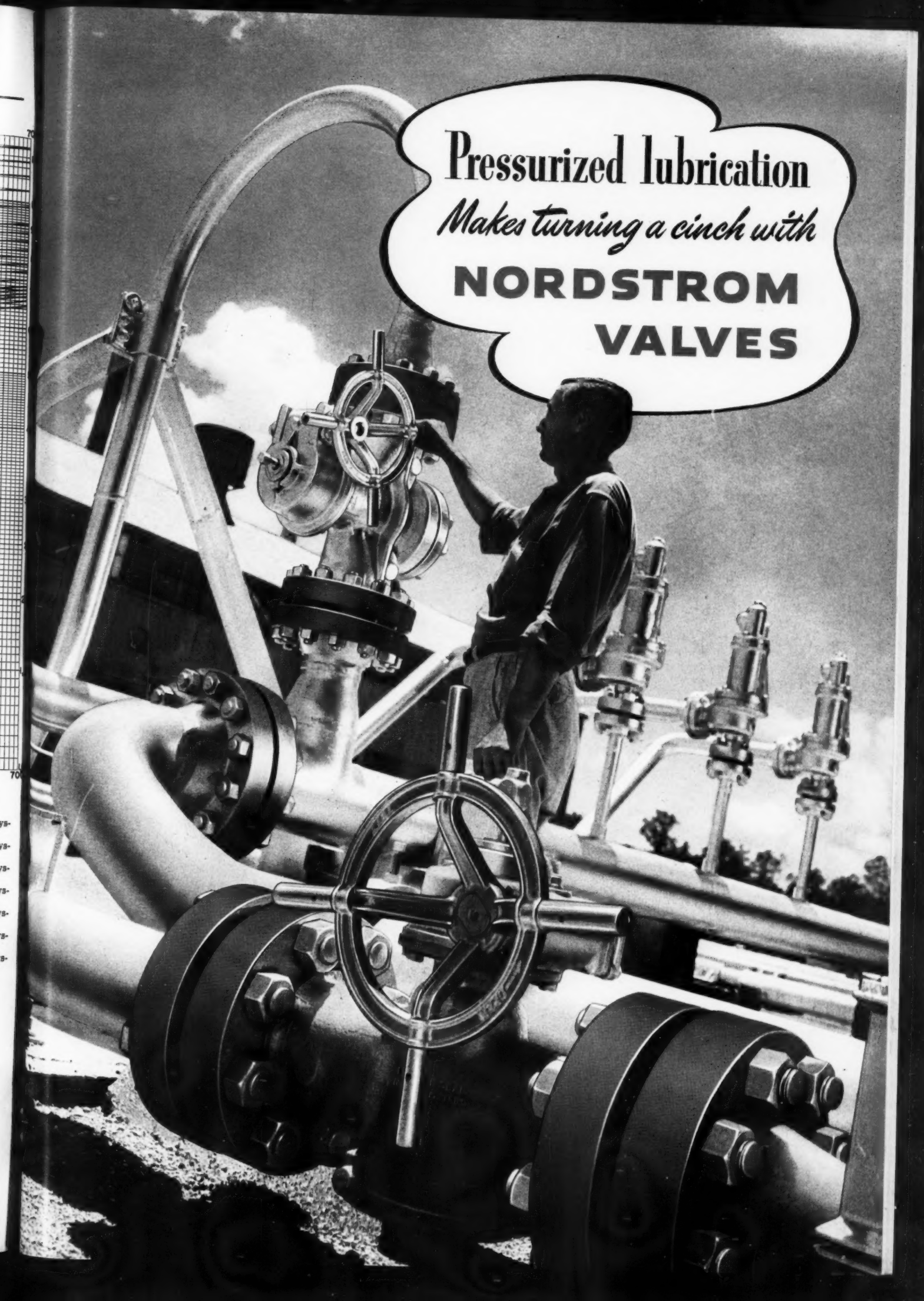


Shown above is one of the 41 working-scale charts included in the booklet on vaporization equilibrium constants and activity coefficients. As reproduced here, the chart is about 15% smaller than actual size in the booklet. The complete booklet contains a reprint of the preceding article (including Figs. 1-7, as shown in the article), and the following 41 full-page detailed working charts, Figs. 8-48:

Fig. No.	Title
8	Fugacity Coefficients of Gases and Vapors.
9	Vaporization Equilibrium Constants for Methane.
10	Vaporization Equilibrium Constants for Ethylene.
11	Vaporization Equilibrium Constants for Ethane.
12	Vaporization Equilibrium Constants for Propylene.
13	Vaporization Equilibrium Constants for Propane.
14	Vaporization Equilibrium Constants for Isobutane.
15	Vaporization Equilibrium Constants for Isobutene and Butene-1.
16	Vaporization Equilibrium Constants for Butane.
17	Vaporization Equilibrium Constants for Butene-2.
18	Vaporization Equilibrium Constants for Isopentane.
19	Vaporization Equilibrium Constants for Pentane.
20	Vaporization Equilibrium Constants for Hexane.
21	Vaporization Equilibrium Constants for Heptane.
22	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 14.7 psia.
23	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 100 psia.
24	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 200 psia.
25	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 500 psia.
26	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 1000 psia.
27	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 2000 psia.
28	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 5000 psia.
29	Vaporization Equilibrium Constants for Paraffin Hydrocarbons, System Pressure = 10000 psia.
30	Vapor Phase Activity Coefficients, $(P_r')_v = 0.5$.
31	Vapor Phase Activity Coefficients, $(P_r')_v = 0.8$.
32	Vapor Phase Activity Coefficients, $(P_r')_v = 1.0$.
33	Vapor Phase Activity Coefficients, $(P_r')_v = 1.5$.
34	Vapor Phase Activity Coefficients, $(P_r')_v = 2.0$.
35	Vapor Phase Activity Coefficients, $(P_r')_v = 4.0$.
36	Vapor Phase Activity Coefficients, $(P_r')_v = 7.0$.
37	Vapor Phase Activity Coefficients, $(P_r')_v = 10.0$.
38	Volatility Index for Paraffin Hydrocarbons.
39	Liquid Phase Activity Coefficients, $(P_r')_l = 0.5$.
40	Liquid Phase Activity Coefficients, $(P_r')_l = 0.8$.
41	Liquid Phase Activity Coefficients, $(P_r')_l = 1.0$.
42	Liquid Phase Activity Coefficients, $(P_r')_l = 1.2$.
43	Liquid Phase Activity Coefficients, $(P_r')_l = 1.5$.
44	Liquid Phase Activity Coefficients, $(P_r')_l = 2.0$.
45	Liquid Phase Activity Coefficients, $(P_r')_l = 4.0$.
46	Liquid Phase Activity Coefficients, $(P_r')_l = 7.0$.
47	Liquid Phase Activity Coefficients, $(P_r')_l = 10.0$.
48	Averaging chart for Volatility Ratios of Intermediate Components.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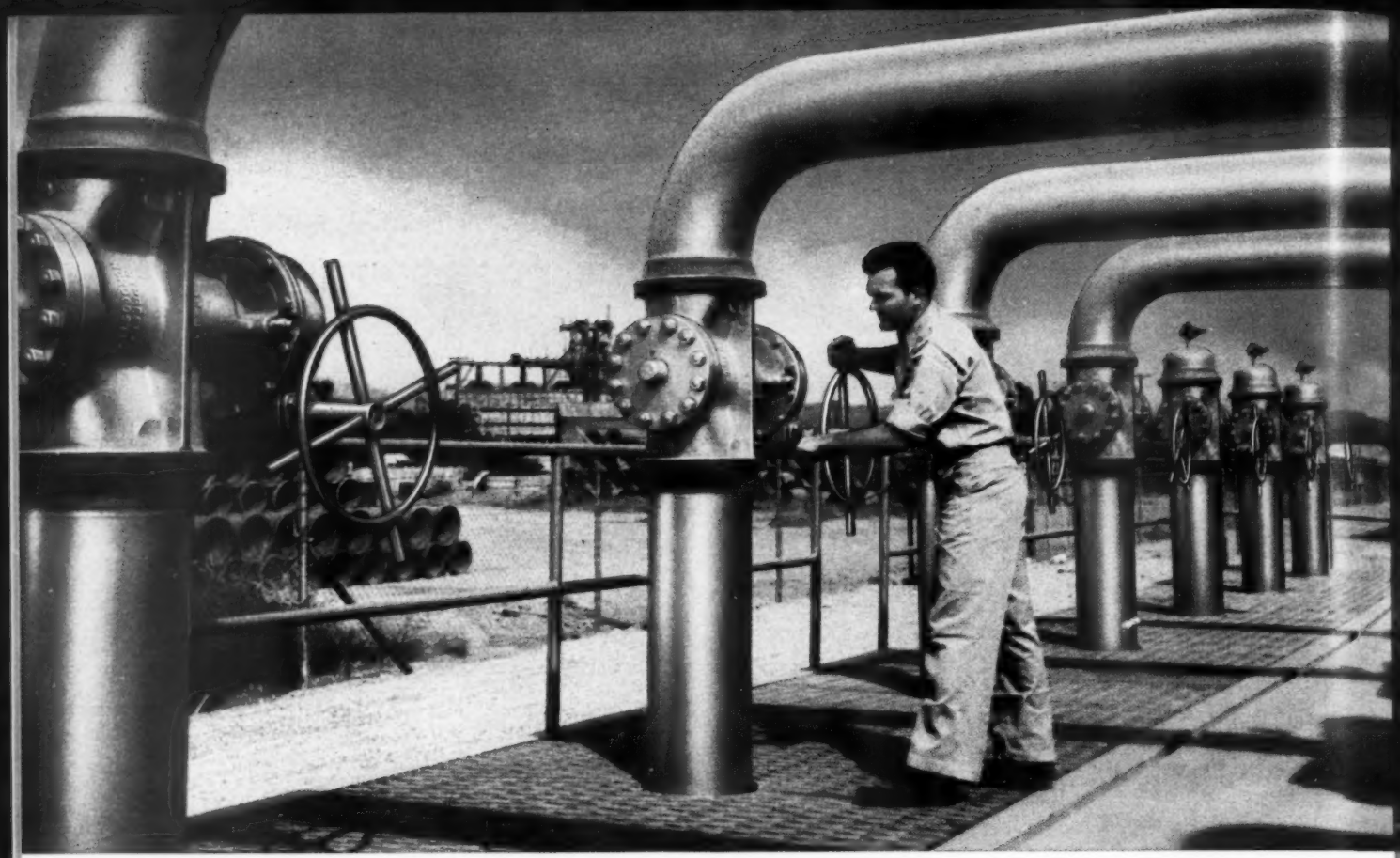

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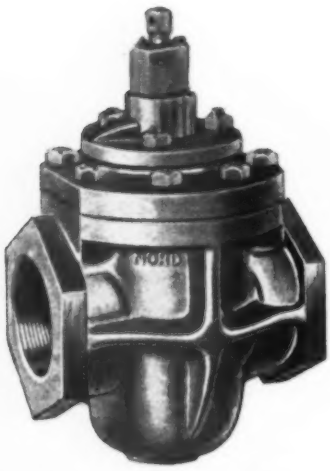

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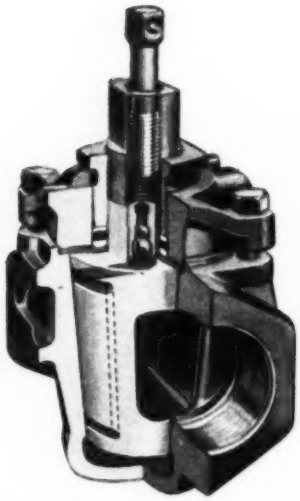

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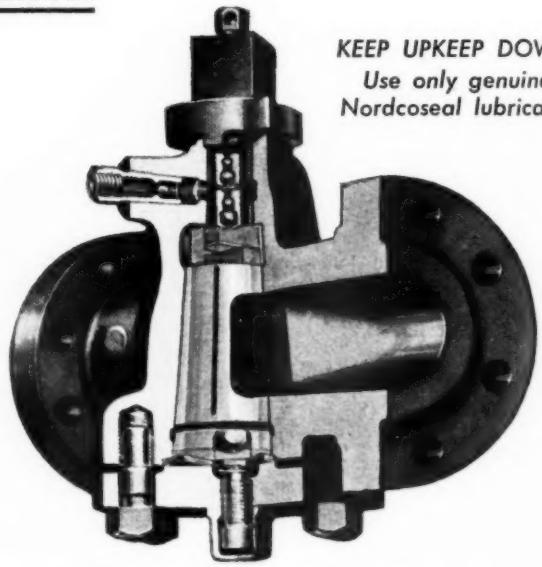

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Practical Tips and Ideas for Improving Operations

Inexpensive Shop-made Valve Jackets Improve Flow in Asphalt Manifolds

BUILT inexpensively in the maintenance shops for a considerable saving over the commercially-available product, steam jacketed gate valves are making the handling of highly viscous asphalt an easy task at Sohio Petroleum Co.'s Latonia, Ky., refinery.

As illustrated in Fig. 1 and in the photograph, the valve jacket is simply a piece of 4-in. channel iron, formed into a U-shape to fit around the valve body. It is welded into place and fitted with three ¾-in. pipe couplings, one at the bottom as a steam outlet and two at the sides for inlets. Jackets are air-pressure-tested at 100 psig., sufficient to handle steam at the pressure required to keep asphalt free flowing. Insulation usually is applied after the valves have been installed.

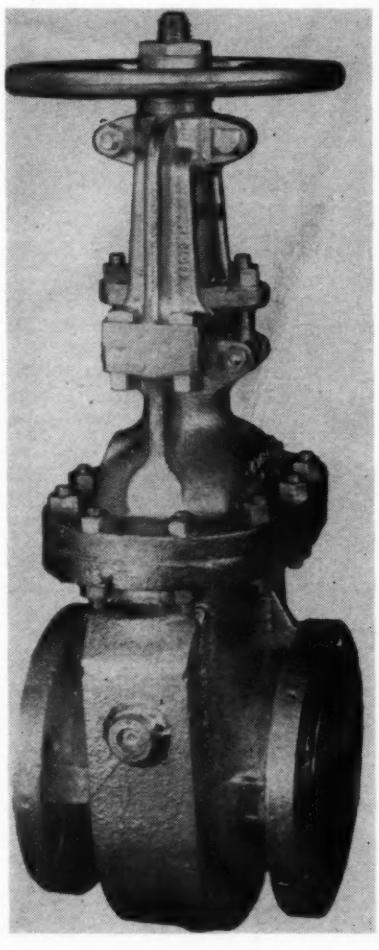
Sohio engineers estimate the jacked valves cost from $15 to $20 each to make. Best price estimate furnished them by a valve manufacturer to do the same job on a conventional gate valve was in the neighborhood of $35 to $45. A new, commercial, steam jacketed valve for this service runs about $350 at regular discount rates, it was stated.

In buliding their own valves, Sohio shop men shape the 4-in. channels on a shop-built hydraulic press on a production line basis. The same design has been applied to both 6 and 4-in. valves, with just one change in the forming dies on the press.

The jacketed units have proved of particular value on valve manifolds in the asphalt plant, where they replace large, cumbersome, metal box enclosures used previously. These boxes, constructed of bolted sheets, were built around the entire manifold, and had appropriate holes cut for the valve stems and wheels. In use, live steam was passed through with no attempt to catch condensate.

Disadvantages of the older method were: 1) the obvious waste of steam, 2) difficulty in operation because of the constant presence of heavy steam vapors in the area around the manifold, and 3) the necessity to completely disassemble the metal box to gain access to the valves for maintenance.

The valve idea was developed by Sohio's boiler shop personnel under the supervision of foreman Joe Mondiek.



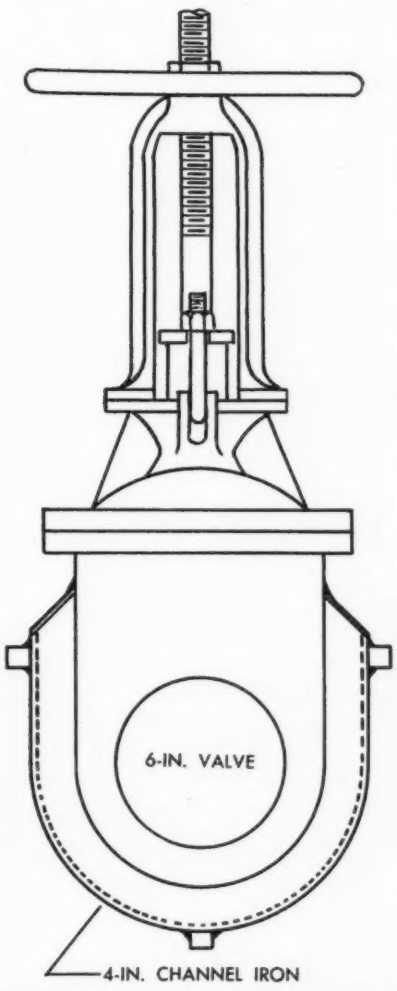


Fig. 1—Sketch and photograph of the inexpensive steam-jacketed valve built in Sohio Petroleum Co. shops

Jig Insures Even Build-up In Metallizing Worn Shafts

WORN shafts which are to be repaired by "metallizing" — spraying weld metal on the worn section—must be held securely and rotated steadily to assure an even build-up of metal. To do this job, maintenance welders at the Bayway refinery of Esso Standard Oil Co. have devised a special fixture, built from scrap parts. The fixture is shown in use in the photograph.

It consists of two lengths of 1½-in. angle iron, a movable support at one end, and a fixed support at the other carrying an adjustable center. The two pieces of angle iron are fastened at each end by a short strip of metal, so that they form in cross section an inverted U, with about a ½-in. slot down the center.

The movable support comprises a piece of ½-in. plate, 3 in. wide, and in the form of an "L". It slides along the bed and can be secured in any desired position by the T-bolt running through the slot in the bed. A bolt tightened securely to the top of this support is ground to a point

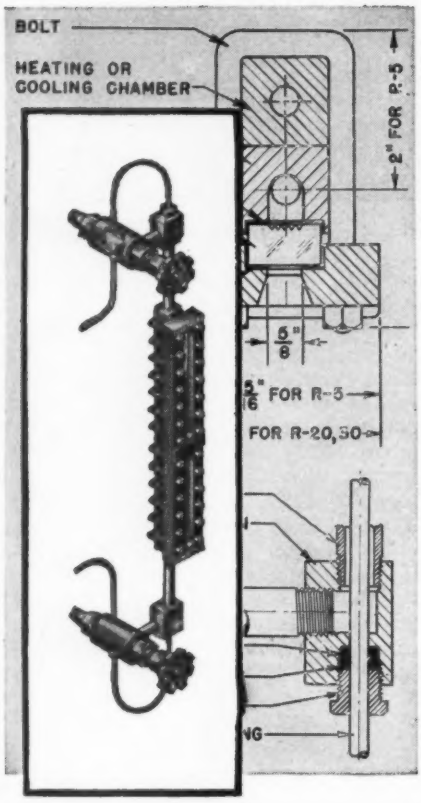


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Illustration shows Internal Tube Model, Reflex Type, with No. 93 Valves. Write for Data Unit No. 17.

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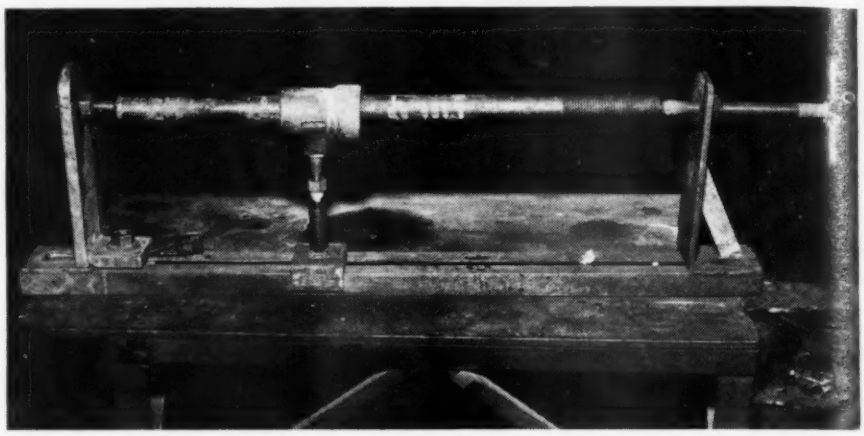

Esso's jig for metallizing worn shafts

and serves to hold and center the shaft at one end.

The fixed support on the opposite end is the same general shape as the movable support, but is welded to the bed and includes a strengthening gusset. Instead of a fixed center, it is threaded to accommodate an old valve stem. The stem is pointed at one end and the handle has been retained.

When long and heavy shafts are being repaired on this fixture, the heat of welding might be high enough to soften the metal and allow it to deform under its own weight. To prevent this, an adjustable height support has been added, which can be placed under the shaft being worked.

This support consists of a U-shaped base which fits over the bed, and a 4-in. length of 1-in. pipe welded vertically to the base. Loosely set in this pipe is a 6-in. lag bolt, riding on a nut which bears against the top edge of the pipe. To the upper end of the bolt has been welded a short length of angle iron, forming a trough in which the shaft being repaired can rest. The trough can be raised or lowered to the proper height by turning the nut on the lag bolt.

Portable Work Holders Speed Cleaning Of Return Bends, Plugs, Pump Parts

CLEANING operations on small parts — return bends, return bend plugs, pump parts, and the like —has been facilitated by a set of portable, work-holding tables built by the maintenance department and used at the Cleves, Ohio, refinery of Gulf Refining Co. Three of the tables are shown in the photograph.

Constructed solidly from discarded 2-in. pipe, welded together in a suitable frame, and with a piece of heavy

Gulf's portable tables for cleaning return bends, plugs, and the like

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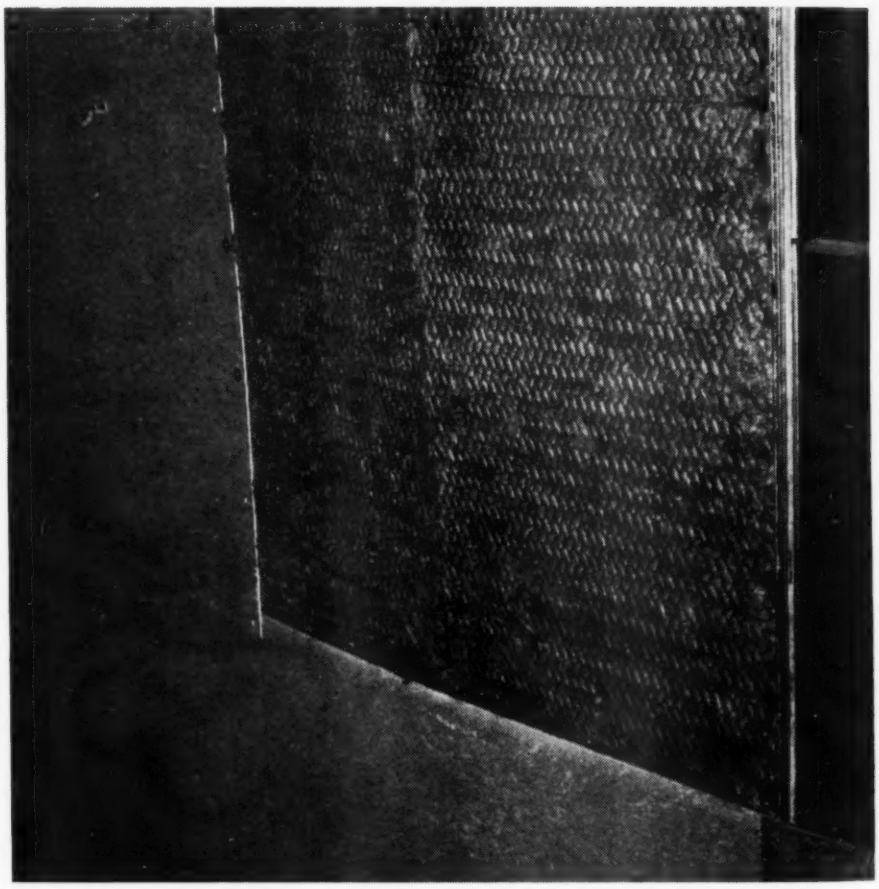
S-88

steel plate for the top, each work table has been designed for a specific job.

The table at the left in the picture is for return bends. Mounted on the top are a pair of large tube ends, into which the two sides of the return bend have been inserted. A piece of bar stock—fastened to the table by a chain—serves as a wedge to hold the return bend in place during cleaning. The 90°-ell on the opening opposite that into which the operator is placing the cleaning tool serves as a deflector for the dust and grit.

The smaller table in the middle of the photograph has a pair of movable, vertical plates on the top which provide a simple vise-type jig for holding an air motor-driven cleaning tool used for return bend plugs. The triangular-shaped table at the right has still another style jig, in this case one for cleaning hot oil pump "caps".

Refinery Develops Low-Cost Insulation Procedure for Hot Oil Storage Tanks



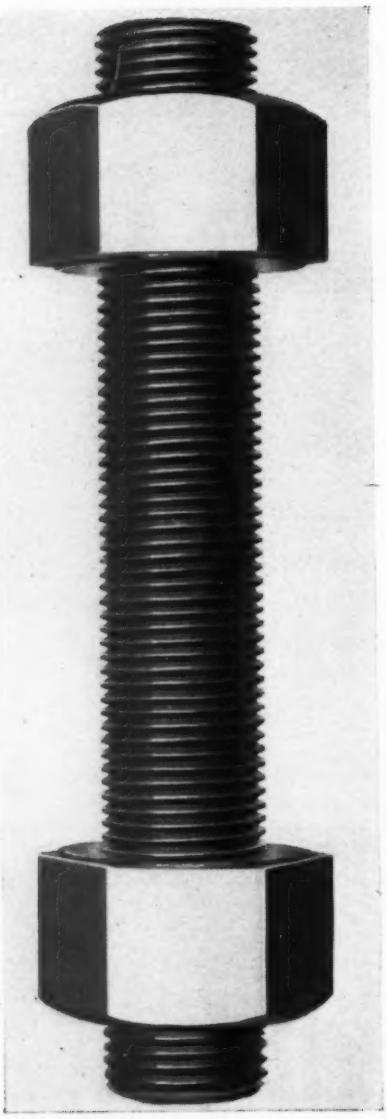
Socony-Vacuum's technique for insulating hot oil storage tanks

AN insulation technique for hot oil storage tanks, developed and used at the Paulsboro, N. J., refinery of Socony-Vacuum Oil Co., Inc., is said to cost less generally than any other comparable duty insulation. In addition, maintenance can be practically eliminated if stainless steel bands, bolts, and washers are used.

The method is illustrated, step by step, in the accompanying photograph. First, lightweight metal channels are clipped in a vertical position to straps wound around the tank. Then a mineral wool blanket is wired into place in the spaces between the channels. Finally, a ⅛-in. thick, asbestos-Portland cement mill board is bolted to the vertical channels, each piece overlapping its neighbors as much as is practicable.

Instead of blankets, loose wool, ground 85% magnesia, or any other type of insulation can be placed in the annular space.

If the top of the tank is not to be insulated, a weather flashing of either some suitable sheet metal or roofing felt may be cemented and banded to the tank to protect the top of the insulation.



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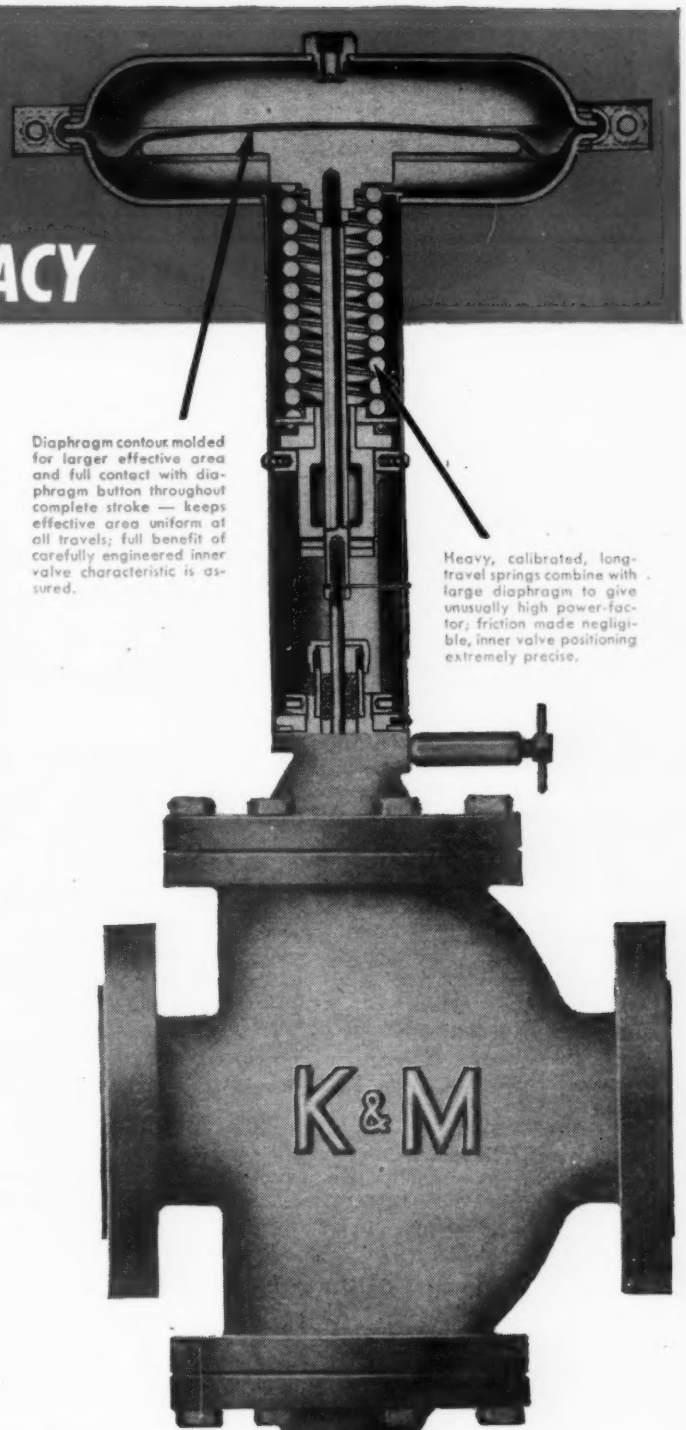

Diaphragm contour molded for larger effective area and full contact with diaphragm button throughout complete stroke — keeps effective area uniform at all travels; full benefit of carefully engineered inner valve characteristic is assured.

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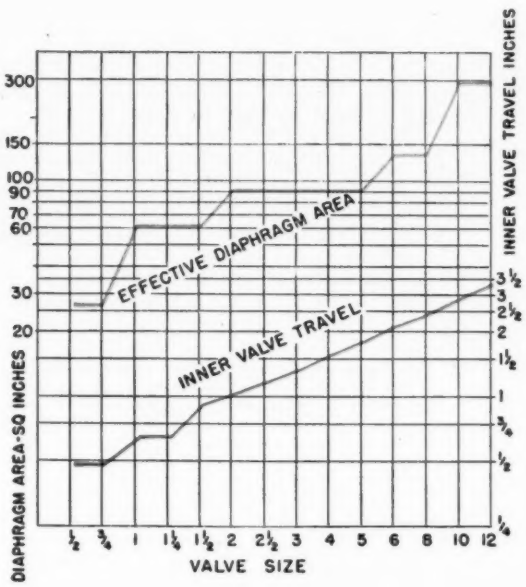

Chart shows effective diaphragm areas and valve travels on K&M Series 1200 and 1400 Kontrol Motor Diaphragm Valves.

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Patent Trends in Petroleum Refining

By Peter J. Gaylor, Editor "The Technical Survey"

Perforated Scraper Blade Lowers Oil in Wax Cake

THE use of a continuous rotary filter is employed in a dewaxing method covered in U. S. 2,484,304 issued to Socony-Vacuum Oil Co. It is pointed out that under ideal conditions the filter operation should be such that substantially all of the oil is drawn during the drying steps by suction through the wax cake into the interior of the drum before the revolving of the rotary filter brings the wax cake to the area where the cake is blown free, scraped and deposited in the wax conveyor.

Actually, however, under operating conditions it has been found that a certain amount of the oil or mixture of oil and solvent adheres to the under surface of the filtering medium and tends to collect between the actual surface of the drum and the filtering cloth. Under such conditions, this adhering oil is blown out of its place of deposition during the interval when gas pressure is applied to the cake from within the drum, thus causing a certain amount of oil to be blown into the wax cake.

This objection has been overcome by using a perforated scraper blade, such as the one shown in Fig. 1, for removing wax from the rotary filter. With such a blade, the wax cake passes over the perforations, but most of the oil blown out of the filter passes through the holes and back into the filter reservoir instead of into the wax conveyor, as heretofore.

A diagrammatic view illustrating the filtering cycle of the rotary drum filter is shown in Fig. 2. As the wax cake 4 sucked up from oil solution 3 is continuously scraped off drum 1 by scraper 8, a cold solvent spray from pipe 9 is played upon the broken-up wax and the oil is washed down through perforations in the scraper (Fig. 1), back into liquid filter reservoir 2, so that substantially oil-free wax is dropped off into conveyor 7.

Carbon Blacks May Replace Metal Soaps in Greases

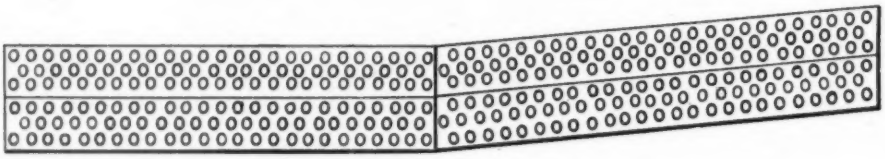
RECENT developments in the grease field have shown that metal soaps are not the only materials capable of imparting a grease-like structure to oil compositions, and that other cheaper materials accomplish this, thus enabling replacement of soaps in at least some compositions.

A number of patents to the Standard Oil Development Co. (U.S. 2,467,146-8 and 2,477,311) disclose that certain carbon blacks, particularly acetylene blacks, impart a colloidal structure to lubricating oil compositions, similar in many respects to the well-known grease structure imparted by soaps. Channel blacks are particulate and their grease structure-forming properties depend on high oil absorption due to small particle size. Acetylene blacks are reticulate in particle structure and have abnormal oil absorptive and structure forming properties.

The acetylene blacks appear in the form of groups of particles in branched chains giving a reticulate or lacy structure which can be detected by means of the electron microscope and which is particularly suitable for the setting up of a good grease structure. Monarch 71, a typical ink black, is an example of a structural acetylene black.

A grease compounded of a mineral oil (such as Mid-Continent base oil of 180 S.S.U. at 210° F.), when mixed with a structural carbon black, forms a good grease, but lacks adhesive qualities. This latter property can be improved by addition of polyisobutylene (to which sulfur is added, apparently to inhibit breakdown). Petroleum hydrocarbon resins obtained from propane extraction of deasphalted petroleum oil residua are also added to improve tackiness and impart cohesiveness.

One composition found to show excellent results as a high temperature metal-adherent grease contains 12% acetylene black, 2% flowers of sulfur, 1% polyisobutylene (60,000-80,000 molecular weight), 20% petroleum resin from bright stock and 65% conventionally refined Mid-Continent oil. Obviously such greases cannot be transparent or light colored.



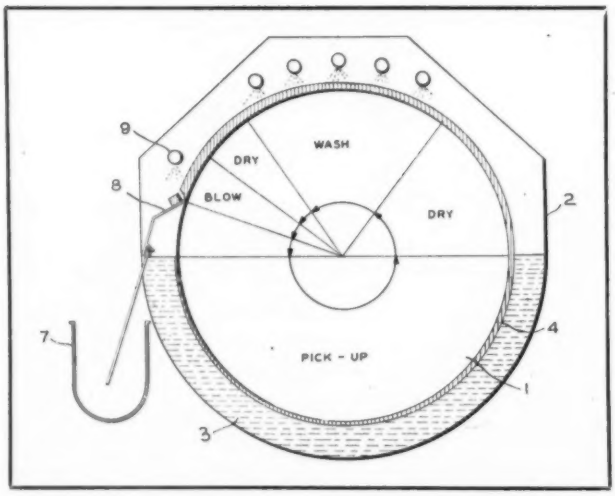


Fig. 1—(Above)—Perforated-type scraper blade employed by Socony-Vacuum Oil Co. to reduce the amount of oil removed with the wax cake in solvent dewaxing operations. (U. S. 2,484,304)

Fig. 2 (Left) — Relation of the perforated scraper blade 8 to the dewaxing filter

Lower Oxidation Products From Hydrocarbons

A PATENT recently issued to the Lubrizol Corp. (U. S. 2,475,605) discloses the oxidation of hydrocarbons (particularly olefins or chlor-hydrocarbons) under controlled conditions to give high yields of lower oxidation products, such as alcohols, ketones and aldehydes. No catalyst is employed but a novel type of reactor and technique are claimed to be responsible for the results reported.

The process is claimed to effect efficient temperature control and thus allow reaction of relatively large amounts of oxygen with relatively small amounts of hydrocarbon in a relatively short time without causing excessive temperatures which would otherwise form unde-

sirably large percentages of higher oxidation products. This factor is said to be responsible for the "truly commercial" conversions obtained.

This cooling effect is mostly attributed to the use of a finned reactor shown in cross-section in Fig. 2. Tube 1 is of stainless steel. Extending into one end of tube 1 is second stainless steel tube 2 having closed bottom 5a. Attached to the outer periphery of tube 2 are U-shaped fins 3 which extend to and fit closely against the inner periphery of tube 1, thus providing a number of laterally contiguous elon-

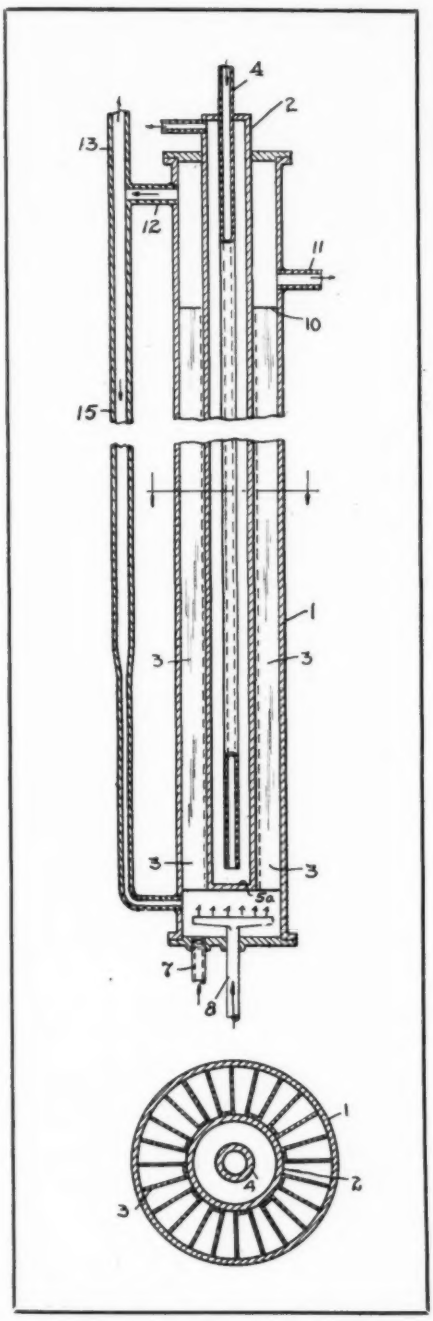
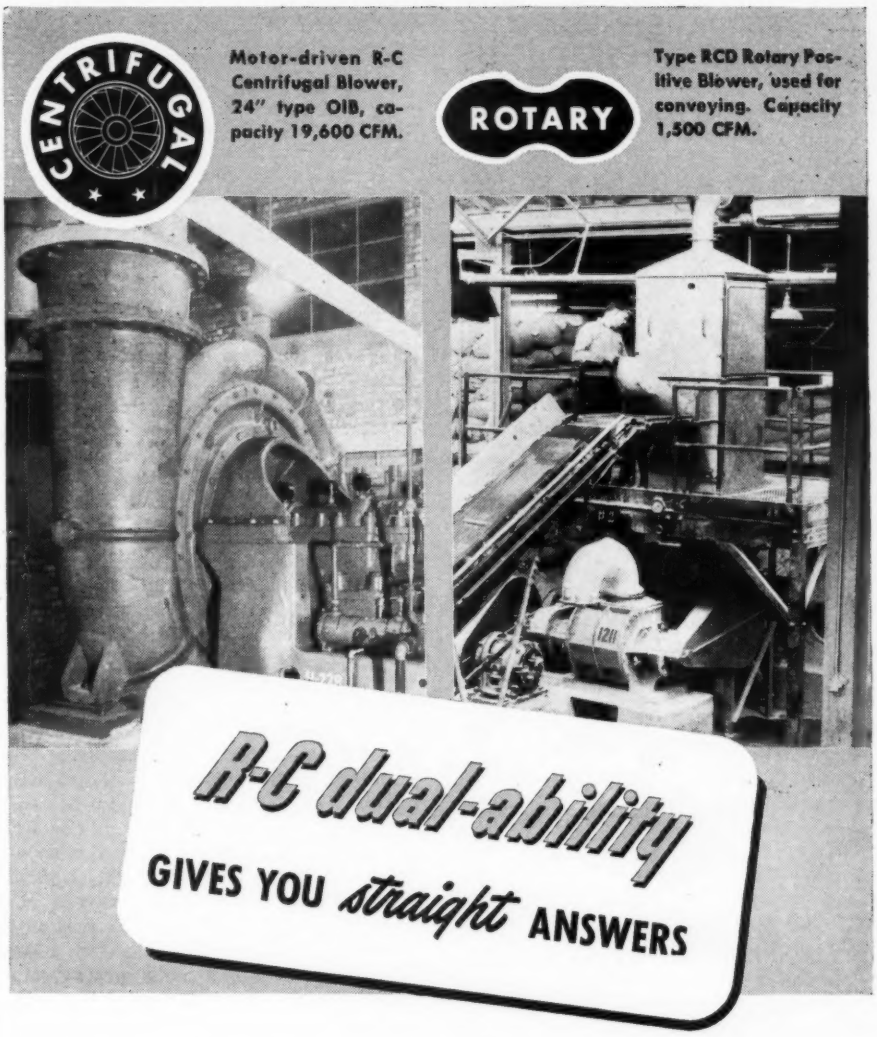


Fig. 2—Details of reactor for oxidizing hydrocarbons to lower oxidation products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gated passages extending axially through the reactor. A third tube 4 extends into inner tube 2 to a point near its lower closed end 5a and is fixed to be connected to a water supply so that water can enter the top of tube 4 and leave through nipple 5 in the top of tube 2.

Hydrocarbon is fed in through inlet 7, while oxygen-bearing gas is supplied through conduit 8 and the reaction mixture is drawn off through outlet 11. Outlet tube 12 joins tube 13 which leads to a condenser above the unit, from which condensed liquid is allowed to run down tube 15, back into reactor 1. Liquid level is maintained at 10.

Benzene has been found to be a good diluent, since it is not oxidized under the conditions specified (150-200 psi, 130°-153° C). The stocks oxidized, on which operating data are given, include diisobutylene, methyl cyclohexane, n-octane, diamylene, isoheptene, and triisobutylene. In the case of diisobutylene, the yields of light and heavy useful oxidation products were 14.4% and 74.5% respectively, based on the hydrocarbon converted, with a conversion of 57.4%. These high figures are claimed to be due mainly to the fact that the material undergoing oxidation is at all times in close proximity to a heat abstracting surface.

Patents Issued in October

The following classified listing gives the patent number, patentee or assignee, and a brief description of all patents believed to be of direct interest to the petroleum processing industries, as contained in the Official Gazettes of the U. S. Patent Office for October 4, 11, 18 and 25, Vol. 627, Nos. 1-4.

Fuels

2,485,297 (Standard Oil Development)—Gasoline emulsion.
2,485,298 (Standard Oil Development)—Breaking gasoline emulsion.
2,485,696 (Universal Oil Products Co.)—Inhibiting gasoline contaminated with iron impurity.
2,485,897 (Standard Oil Co.—Ind.)—Cyclopentane-triptane superfuel.
2,485,964 & 6 (Shell Development Co.)—Methyl cyclopentene.
2,485,965 (Shell Development Co.)—Cyclohexane.

Conversions

2,483,485 (Standard Oil Development)—High velocity fluid solids technique.
2,483,487 (Phillips Petroleum Co.)—Separation of volatilizable metal halides from adsorbents.
2,483,494 (Standard Oil Development Co.)—Catalytic converter for short time reactions.
2,483,877 (Phillips Petroleum Co.)—Continuous polymerization.
2,483,923 (Phillips Petroleum Co.) — Vertical type internal outlet header for catalyst chambers.
2,483,929 (Phillips Petroleum Co.)—Catalytic dehydrogenation of aliphatics.
2,484,384 (California Research) — Propylene polymerization.
2,485,073 (California Research)—Hydrocarbon conversions with vanadium oxide-sulfide catalyst.
2,485,260 (Standard Oil Development)—Hydrocarbon conversion in presence of silica-magnesia catalyst.
2,485,315 (Standard Oil Development Co.)—Controlled severity fluid coking.
2,485,316 (Standard Oil Development Co.)—Slide valve for fluidized solids.
2,485,318 (Standard Oil Development) — Contacting solids and gases.
2,485,542 (Socony-Vacuum Oil)—Protection of heat transfer media (molten metal).
2,485,906 (Phillips Petroleum Co.)—Multi-activity zone catalytic conversion.
2,485,927 (Phillips Petroleum Co.)—Catalytic dehydrogenation with alumina-baria.
2,486,229 (Socony-Vacuum Oil Co.)—Cracking in presence of finely divided catalyst.
2,486,361 (Union Oil Co.)—Catalytic conversion with Gp. VIII and VI compounds.
2,486,368 (Phillips Petroleum Co.)—HF-BF_3-H_2O isomerization catalyst.

Refining

2,483,492 (Phillips Petroleum Co.)—Purification of benzene and homologs.
2,483,625 (Union Oil Co.)—2-Stage azeotropic distillation of non-aromatic hydrocarbons from toluene.
2,483,948 (Phillips Petroleum Co.)—Treating tower containing solid contact material.
2,484,304 (Socony-Vacuum Oil)—Dewaxing oil with continuous rotary filter.
2,484,305 (Phillips Petroleum)—Separation of unsaturated hydrocarbons with paraldehyde and tetra-o-silicate.
2,484,381 (California Research Corp.)—Purification of carbonyl sulfide contaminated hydrocarbon gases.
2,484,728 (Socony-Vacuum Oil)—Wax separation.
2,485,070-1 (Phillips Petroleum) — Inhibiting polymerization of furfural in extractive distillation, with pyridine, etc.
2,485,265 (Standard Oil Development)—Separation of triisobutylene isomers.
2,486,014 (Atlantic Refining Co.)—Solvent dewaxing.

Chemicals

2,483,566 (Universal Oil Products Co.)—Aromatic ketonic product.
2,483,778 (Standard Oil Development)—Inhibition of resin growth from diolefins.
2,483,824 (Shell Development)—Derivatives of 2,1-benzopyran.
2,483,852 (Shell Development Co.) — Acrolein diacetate.
2,483,853 (Shell Development Co.)—Monohydroxy dinitriles and esters.
2,483,863 (Standard Oil Development)—Diolefin extraction.
2,483,869 (Phillips Petroleum Co.)—Separating ethylene from gases.
2,483,886-7 (Phillips Petroleum Co.)—Catalyst comprising dispersed alkali metal and carbon black for polymerization.
2,483,903 (Phillips Petroleum Co.)—Addition product of butadiene and furfural.
2,484,061 (Cities Service Oil Co.)—Dichloro methyl sulfenyl chloride.
2,484,268 (Socony-Vacuum Oil) — Allyl thiophenes.
2,484,369 (Shell Development)—Liquid condensation polymers of bis (hydroxy-alkyl) sulfides and polysulfides.
2,484,370 (Shell Development)—Liquid sulfoalkylene-oxyalkylene copolymers.
2,484,702 (Phillips Petroleum Co.)—Hydration of olefins to alcohols.
2,485,329 (Standard Oil Development Co.)—Ether purification.
2,495,335 (Standard Oil Development Co.)—Polymer separation.
2,485,342 (Standard Oil Development Co.)—Oxidizing naphthalene.
2,485,454 (Standard Oil Development Co.)—Low temperature polymerization using inorganic diluent.
2,485,687 (Universal Oil Products Co.)—Arsenic trichloride.
2,485,911 (Anglo-Iranian Oil Co.)—Resin by reacting petroleum extract with sulfur dioxide.

Lubricants

2,483,499 (Standard Oil Development)—Reacted paraffin wax sulfonyl chloride as lube oil addition agent.
2,483,501 (Standard Oil Development)—Double salts of phenol sulfonic acids.
2,483,505 (Standard Oil Development)—Compounded lube oil containing phenol sulfide metal salt reaction product.

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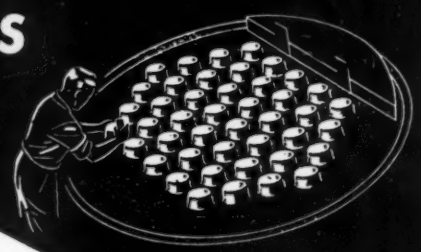

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Patent Trends

2,483,571 (Pure Oil Co.)—Reacting organic substances with phosphorus sesquisulfide.
2,483,600 (Pure Oil Co.)—High viscosity extreme pressure base additive by air blowing fatty material.
2,483,736 (Socony-Vacuum Oil Co.)—Sulfurization of reaction product of phosphorus pentasulfide and unsaturated acyclic ketone.
2,483,800 (Standard Oil Development)—Grease containing sulfonic acid salt.
2,483,859 (Shell Development)—Anti-ring sticking lubricating composition.
2,484,146 (E. F. Houghton & Co.)—Lubricating composition containing a soap and soluble phosphoric acid salt.
2,484,257 (Standard Oil Co.—Ind.)—Oils inhibited against oxidation by dithiooxamide.
2,484,843 (Standard Oil Co.—Ohio)—Phosphorus sulfide-treated hydrogenated sperm oil as lubricant additive.
2,485,150 (Rohm & Haas)—Oil containing oil soluble petroleum sulfonate and alkyl phenoxyethoxyethoxyethanol.
2,485,341 (Standard Oil Development)—Lube oil containing rust inhibitor.
2,485,376 (Rohm & Haas)—Corrosion-resisting lubricating compositions.
2,485,861 (Campbell et al)—Sulfonate-compounded lube oil.
2,486,080 (Atlantic Refining Co.)—Testing detergent properties of lube oils.
2,486,130 (Dow Chem. Co.)—Lubricant containing aluminum powder, soap and fatty oil.
2,486,188 (Sinclair Refg.)—Detergentized lube oil.

Hydrocarbon Synthesis

2,483,512 (Standard Oil Development)—Hydrocarbon synthesis process catalyzed by oxidized and reduced iron.
2,483,771 (Standard Oil Development)—2-Stage process for synthesis of hydrocarbons.
2,483,850 (Standard Oil Development)—Reclaiming contaminated iron catalyst.
2,484,249 (Texaco Development)—Carbon monoxide-hydrogen gas mixtures.
2,485,945 (Stanolind Oil & Gas Co.)—Iron hydrocarbon synthesis catalyst.
2,486,243 (The Texas Co.)—Simultaneous dehydrogenation and hydrocarbon synthesis with fluidized catalyst in single reactor.

Specialties

2,485,276 (Standard Oil Development)—Inhibiting corrosion caused by liquid aluminum halide catalysts.
2,485,309 (Standard Oil Development)—Inhibiting corrosion of iron with methylol melamine condensate.
2,485,321 (Shell Development Co.)—Bitumen rust inhibitor composition.
2,485,625 (Armstrong Cork Co.)—Polisobutylene-asphalt composition.

Catalysts

2,483,782 (Standard Oil Development)—Plural silica-containing hydrogel catalysts.
2,484,258 (Universal Oil Products)—Spherical hydrocarbon cracking catalyst.
2,484,284 (Socony-Vacuum Oil)—Gelation of hydrasol in electrical orienting.
2,485,050 (Phillips Petroleum Co.)—Recovering aluminum chloride from hydrocarbon complex.
2,485,249 (Davison Chem.)—Hydrogels.
2,485,626 (Houdry Process Corp.)—Leached kaolin as cracking catalyst.

Miscellaneous

2,484,009 (The Texas Co.)—Internal combustion engine.
2,485,258 (Standard Oil Development Co.)—Electrodepositing lead on copper.
2,485,317 (Standard Oil Development Co.)—Plaster of Paris.
2,485,424 (Socony-Vacuum Oil Co.)—Viscosimeter.
2,485,916 (Phillips Petroleum Co.)—Solvent extraction of cottonseed oil.

How to Obtain Patents

Readers may obtain copies of U. S. patents from the Patent Office at 25 cents each. Order by patent number direct from the Commissioner of Patents, Washington 25, D. C.

Accurate Viscosimeter Employs Synchronous Motor System

In addition to the viscosimeter described below, this month's review of new improved devices used in petroleum processing and handling operations on which patents have been issued recently includes:

- **Wear reduced in gear pumps by change in outlet location**
- **Scrubber and trap combined in one laboratory gas device**

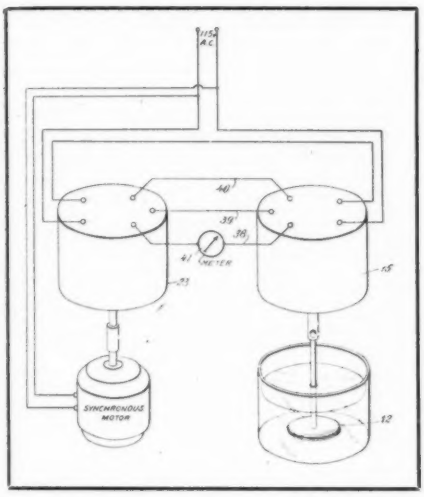

Fig. 1—Two Selsyn units, 15 and 23, improve accuracy of electrically operated viscosimeter (U. S. 2,485,424)

LIQUID VISCOSITY can be measured accurately by the use of an electric Selsyn-motor system for driving a rotating object in the fluid. The method is said to overcome objections to the use of a direct-drive motor to the disk in the liquid, where the no-load current is extremely large compared to the additional current due to the frictional loading by the liquid being measured.

The apparatus is shown schematically in Fig. 1. It is found that the Selsyn motor, which was developed mainly for transmitting a low torque mechanical motion such as dial indication, could be continuously rotated with a current input that is negligible compared to the current input due to slight loading of the driven object in the liquid.

It was found that if a pair of matched Selsyn units, 15 and 23, were connected at equivalent rotor terminals—lines 38, 39 and 40—and both primaries of the units were energized from the same line voltage source, the rotors would line up in phase.

By connecting the rotating object, or disk, 12, in the liquid to be measured with the rotor of unit 15, and driving the rotor of unit 23 at constant speed by a synchronous motor, the entire system will be in synchronous motion.

If no viscous drag is met by disk 12, the current flow in line 38 will be negligibly small; for example, 0.02 milliamp. Therefore, a milliammeter 41, suitably calibrated, will measure the current flow changes due to viscous drag on disk 12. Any loading on disk 12 will produce a current in line 38 due to a phase unbalance between the Selsyn units and substantially proportional to the viscosity of the liquid.

Since the variation in current with viscosity is substantially a straight line, the meter 41 can be calibrated to read directly in viscosity. If desired, a wattmeter can be used, connecting it to two or all three of the lines 38, 39, and 40.

U. S. 2,485,424, issued October 18, 1949, to Paul B. Weisz, assignor to Socony-Vacuum Oil Co., Inc.

Reduce Wear in Gear Pumps By Altering Outlet Location

WEAR IN GEAR-TYPE pumps can be reduced considerably by revising the location of the outlet ports. In conventional design the outlet pressure, being materially greater than the inlet pressure, has the effect of pushing the gears away from each other with the result that the gear shafts are subjected to extreme wear and leakage clearances develop in a relatively short time, reducing pump efficiency.

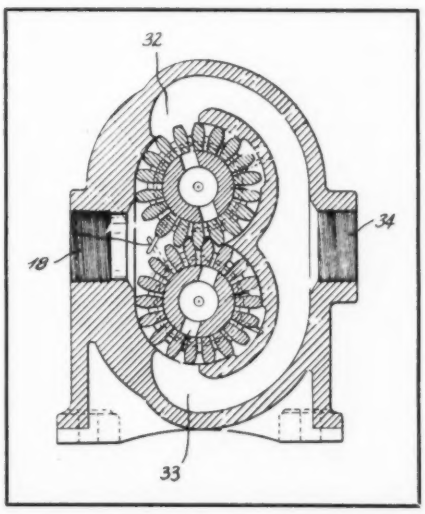

Fig. 2 — Redesigned outlets in gear pump reduce internal wear and increase efficiency (U. S. 2,484,917)

The improved pump is illustrated in Fig. 2, with main inlet at 18 and discharge at 34. Outlet ports 32 and 33 are so located that the outlet pressure has a balancing or neutralizing effect on each gear. In effect, the gears virtually float within the housing.

U. S. 2,484,917, issued October 18, 1949, to John A. Vertson, Brea, Calif.

Scrubber and Trap Combined In Single Laboratory Device

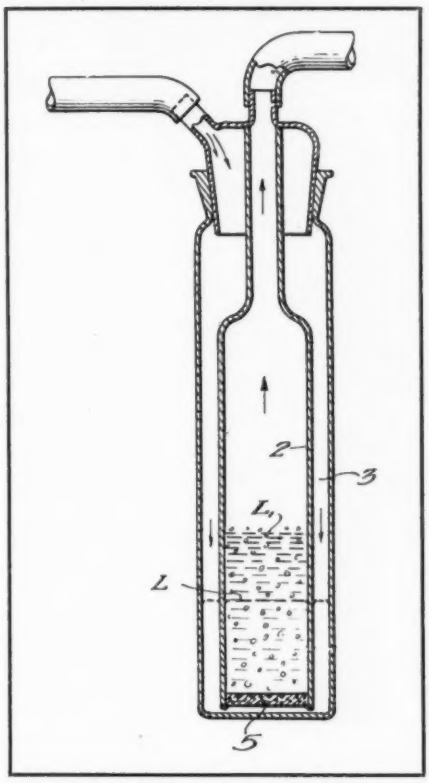

Fig. 3—Combination gas scrubber and trap for laboratory apparatus (U. S. 2,485,739)

THE FUNCTION OF A TRAP is combined with that of a scrubber in a single vessel designed as a laboratory gas scrubbing bottle.

The device is shown in Fig. 3. Incoming gas passes down through the annular space 3, thence through a distributing disk 5 into the wash chamber 2. The disk 5 may be of fritted glass, or other porous material, or a perforated plate.

Washing liquid is placed in the lower part of the bottle only, say to level *L*. Then, under operating conditions, its surface in tube 2 will rise to level L_1, about one-third to one-half the height of the larger portion of tube 2. A change in pres-

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sure will allow the liquid level to drop in tube 2 and rise in annular space 3. However, with the volume in space 3 equal to, or greater than, that in tube 2, liquid will not back up into the gas inlet line.

U. S. 2,485,739, issued October 25, 1949, to Warren W. Johnstone, assignor to Universal Oil Products Co., Chicago.

Other Recent Patents

The following classified listing covers remaining patents issued during the month of October believed to be of interest or value to petroleum processing and handling operations.

Catalytic Reactors

2,483,494 (Std. Oil Development Co.)—Catalytic converter.
2,483,923 (Phillips Petroleum Co.)—Vertical type internal outlet header for catalyst chambers.
2,483,948 (Phillips Petroleum Co.)—Treating tower containing solid contact material.
2,485,318 (Std. Oil Development Co.)—Vessel designed for hydrocarbon synthesis.
2,486,200 (The Lummus Co.)—Clay flow baffle.
2,486,229 (Socony-Vacuum Oil Co., Inc.)—Catalytic reaction vessel.

Processing, general

2,484,304 (Socony-Vacuum Oil Co.)—Continuous rotary filter for dewaxing oil.
2,484,904 (S. Pennella)—Leak stopper for condenser tubes.
2,484,918 (Vulcan Copper & Supply Co.)—Liquid-vapor contact column.
2,485,038 (M. Culkosky)—Device for washing and cooling compressed gas.

Tanks

2,485,557 (Chicago Bridge & Iron Co.)—Lifter roof tank.
2,485,613 (Chicago Bridge & Iron Co.)—Guide for lifter roof tanks.
2,485,614 (Chicago Bridge & Iron Co.)—Stabilizing and guide apparatus for lifter roofs.
2,485,683 (Chicago Bridge & Iron Co.)—Leveling system for lifter roof tanks.

Valves

2,483,518 (The Duriron Co.)—Plug cock valve.
2,484,199 (W. B. Walger)—Throttle valve for steam driven engine.
2,484,622 (Taylor Instrument Cos.)—Flow diversion valve with leak detector arrangement.
2,484,940 (G. W. Franzheim)—Automatic cut-off valve for gas lines.
2,485,092 (Fluid Control Engrg. Co.)—Pressure-tight valve seat.
2,485,831 (The Duriron Co.)—Plug cock valve.
2,485,942 (R.R.P. Turner)—Valve position indicator.

Instruments

2,483,532 (R. C. de Palacio)—Automatic level gage for liquids contained in tanks.
2,486,080 (Atlantic Refining Co.)—Apparatus for testing detergency of lube oils and their additives.
2,486,199 (A. O. Nier—University of Minnesota)—Mass spectrometer leak detector.

Miscellaneous

2,483,713 (E. Seaver)—Combined pipe wrench and vise.
2,484,279 (Phillips Petroleum Co.)—Apparatus for testing corrosion in process stream.
2,484,942-2,484,943 (Ansul Chemical Co.)—Nozzle for spraying dry chemical fire extinguishing agents.
2,484,993 (M. Gruber)—Rotary pump using cylindrical roller pistons.
2,485,392 (Burgess-Manning Co.) — Silencer with cloth, gas-conducting conduit.

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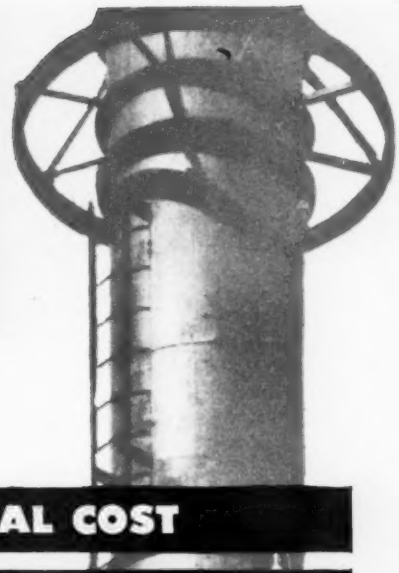

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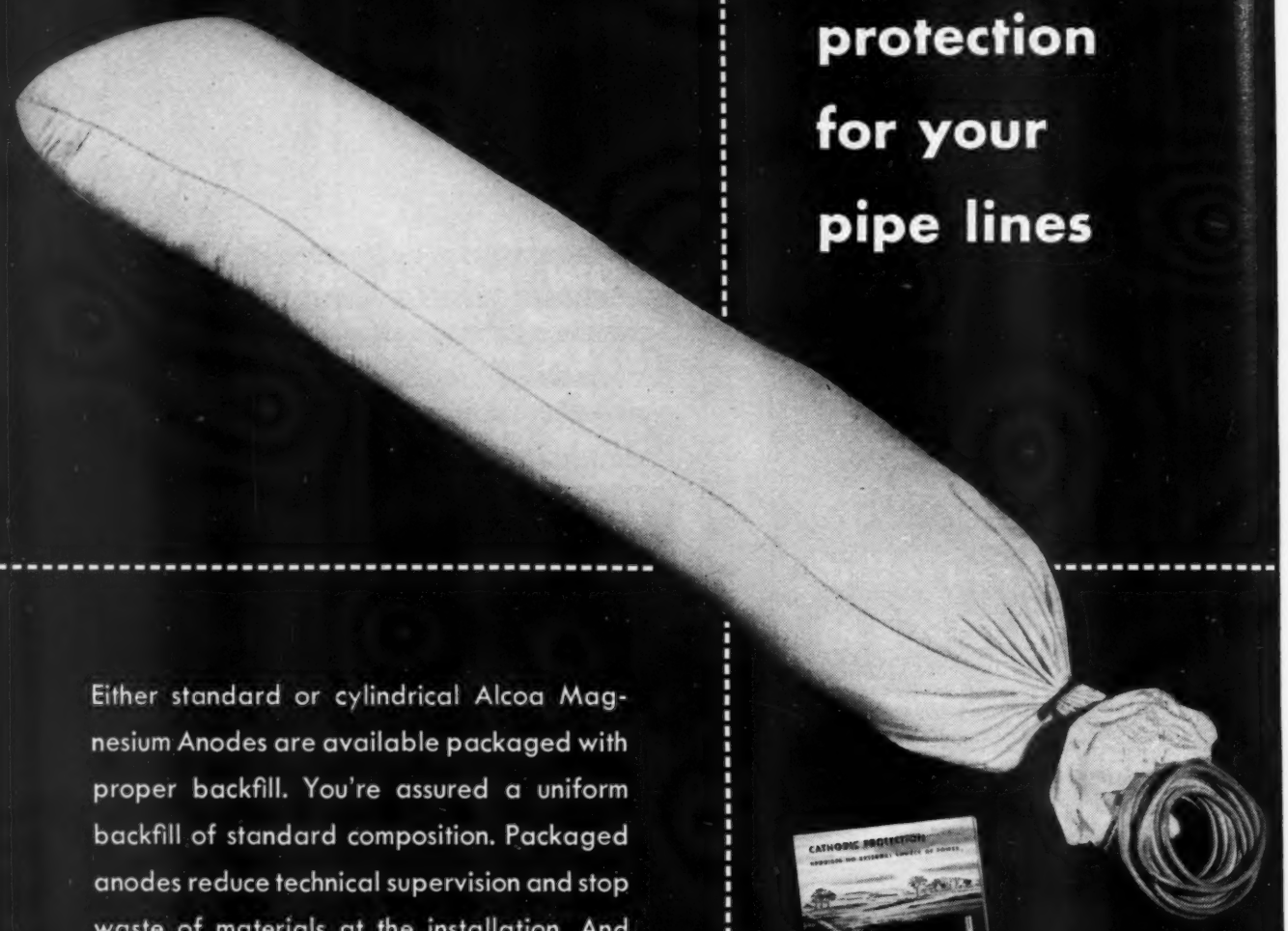

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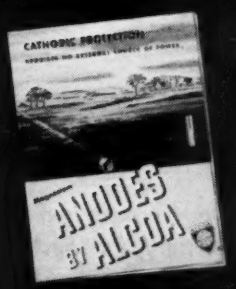

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Serving the Petroleum Processing Industry

Instrumentation Course Announced

Fischer & Porter Co. has announced that its next instrumentation course will be held at the Hatboro, Penna., plant, January 23 through 27, 1950. The course will cover manufacture, calibration, installation, operation, and maintenance of primary and secondary process control instruments.

Users of the Flowrator line of products will find the course valuable, it is stated. Further details can be obtained from the company, at East County Line Rd., Hatboro, attn.: H. R. Holden, service manager.

Graver Appoints General Manager

Mr. Sulcer

Henry T. Sulcer has been appointed general manager of Graver Water Conditioning Co., 216 West 14 St., New York City. He had been general auditor of the parent company, Graver Tank & Mfg. Co., Inc., which he joined in 1948. Aiding Mr. Sulcer as new assistant general manager is Edward E. Welp, formerly sales manager of Graver's Water Treating Division. Mr. Welp will make his headquarters in the Chicago office. S. D. Barr, previously in charge of Eastern District Sales, has been advanced to general sales manager with offices in New York. The Technical Division of the firm now is headed by Vincent J. Calise.

New field offices recently established include: Suite 1101, Hippodrome Bldg., Cleveland, under Herman Ross; and Suite 1012, Commercial Trust Bldg., Philadelphia, under Robert Schenker.

Wolcott Up at Lukens Steel

Robert W. Wolcott, president of Lukens Steel Co. since 1925, has been named chairman of the board, and Charles Lukens Huston, Jr., vice president and executive assistant to the president since Feb., 1948, has been elected president of the company. The men assumed their new duties as of Oct. 30, which date marked the beginning of the firm's 140th year in the business of iron and steel making and fabricating in Coatesville, Pa.

Mr. Wolcott has been associated with Lukens since 1922, serving first as manager of its warehouse and fabricating division in New Orleans. Mr. Huston, a lineal descendant of Isaac Pennock, a founder of the business in 1810, became associated with Lukens in 1939, after 10 years with Armco Steel Corp.

Sargent Builds New Chicago Plant

Completion of a new, one-story steel, concrete and brick building for the Chicago offices and plant of E. H. Sargent & Co., manufacturers and distributors of laboratory instruments, apparatus, and chemicals, has been announced. The new plant is located at 4647 West Foster Avenue, Chicago 30. The new phone number is SPring 7-2700.

Occupying approximately three acres on the five-acre tract of land, the building houses complete engineering, production, merchandise handling, and warehouse facilities. The packing room is equipped with the latest type belt conveyor system. Shipping facilities are a rail loading dock, rail spur, and two inside motor truck docks.

Petro-Chem Names Sales Manager

T. B. Leech, who has been associated with the oil industry since he went to work for The Texas Co. in 1916, has been appointed sales manager of Petro-Chem Development Co. He has been for many years with engineering or engineering sales organizations handling refinery equipment. Since 1941, he was manager of refinery sales for Bethlehem Supply Co., resigning from that position in August, 1949, to go with Petro-Chem.

Swift's Oil Division Moves

Transfer from Chicago to Hammond, Indiana, of the administrative offices of the Industrial Oil Division of Swift & Co. has been announced by F. E. Lacey, manager. The move will be completed about January 1, and will include executive personnel, raw material buying, sales representatives, and clerical staff, centering all activities at the main manufacturing location at 165th St. and Indianapolis Blvd., Hammond.

Hyster Expands in California

The Hyster Co. has opened a new industrial truck retail sales and service building at 4445 Third St., San Francisco 24, Calif., where a staff of 18 under R. L. Golden as manager will serve 43 counties of northern California and 11 counties of western Nevada.

William H. Kilkenny has been made the new general manager of the firm's southern California store at 5301 Pacific Bldg., Huntington Park.

Glitsch Appoints New York Manager

Mr. Lindskog

Gordon W. Lindskog, assistant manager of the New York office of Fritz W. Glitsch & Sons, Inc., of Dallas, manufacturers of bubble towers and internals, has been named manager of that office. Previously associated with M. W. Kellogg and National Transit Pump & Machine, Mr. Lindskog will be responsible for the territory including New York, Pennsylvania, Delaware, Maryland, the eastern seaboard and eastern Canada. He succeeds Robert W. Fowler, who moved to Dallas recently as general manager of sales.

Hammel-Dahl Expands Operations

Hammel-Dahl Co., Providence, R. I., has announced that their control valves are now being manufactured in England by the firm of J. Blakeborough & Sons Ltd., at Brighouse, Yorks. In the valve business approximately 140 years, Blakeborough employs over 1200 people, including staffs in research, engineering, and manufacturing.

The British firm will operate substantially in the British Empire outside of Canada, the Scandinavian countries, the Near East, and will offer service on all Hammel-Dahl products scattered over most of the Eastern Hemisphere.

NEW TRISTAND VISE has Handy Tool Tray

RIDGID's New Tristand is now your on-the-job work bench

. . . Trays available for your old model Tristand.

Legs fold in and chain for easy carrying. With new tray Tristand won't fold up in use.

● All your tools are ready at hand with this new RIDGID work-saver pipe vise. Tool tray keeps them in easy reach—eliminates stooping, speeds up work. New Tristand is easy to set up and take down, tray attaches in a jiffy. Legs have rubber feet to prevent "creeping." RIDGID's LonGrip tool-steel jaws have bulldog grip but are easy on polished pipe and tubing. Yoke vise, 2½" capacity; chain vise, 4." Buy the new work-saver RIDGID Tristand from your Supply House.

RIDGID

WORK-SAVER PIPE TOOLS

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News of Suppliers

Personnel Changes

The Austin Co.—A. T. Waidelich has been named vice president in charge of research. Mr. Waidelich, who joined the company as a structural designer in the New York district offices in 1936, has been assistant director of research at Cleveland headquarters since 1941. He is credited with major responsibility for the development of the H-section welded truss.

Cooper Alloy Foundry Co., Hillside, N. J.,—J. L. Lessman has been appointed manager of valve and fitting sales. Mr Lessman has been with Cooper Alloy since 1946 as assistant foundry superintendent.

Magnesia Insulation Manufacturers Association, Washington, D. C.,—Marshall F. Allen now is manager, replacing Utley W. Smith, who resigned to accept a position with **Ehret Magnesia Mfg. Co.**

Fluor Corp., Ltd.,—Owen W. Gaudern has been promoted to the position of manager of purchases. Mr. Gaudern, who joined Fluor in 1934 and has been concerned with a number of assignments in the petroleum field, will make his headquarters in Fluor's main offices in Los Angeles.

Dowell Inc., Tulsa, Okla., has announced two transfers of personnel. Dewey Tennyson, development engineer in New Orleans, has moved to Seminole, Okla., and Edward W. Slavik, development engineer from Hobbs, N. M., has taken Tennyson's post in New Orleans.

Hooker Electrochemical Co.—Harris C. Miller, with the firm since 1941 in process and plant engineering capacities, has been promoted to the sales staff and assigned to the New York City area with headquarters at 60 East 42nd. St.

Air Reduction Co., Inc.—H. R. Salisbury has been named president of **Air Reduction Sales Co.** He has been with the organization over 23 years in various executive capacities. Appointed vice presidents were H. F. Henriques, general sales; J. J. Lincoln, Jr., railroad sales and sales service; S. B. Stouffer, distribution; and N. L. Wisser, field office management.

American Brake Shoe Co.—Harry C. Platt has been appointed vice president of the Engineered Castings Division and William H. Starbuck vice president of the Kellogg Division.

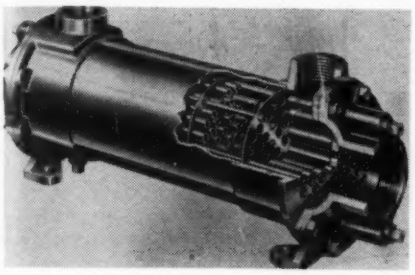
Peerless Pump Div., Food Machinery and Chemical Corp.—Gerald F. Twist has been named manager of this division, and will make his headquarters at Los Angeles.

What's New!

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

Reviewed by WILLIAM C. UHL, Equipment Editor

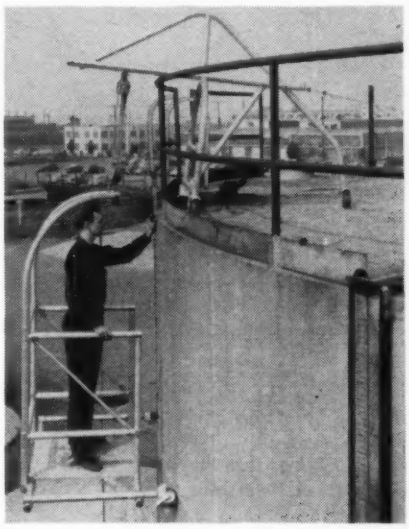
1—Stainless Steel Exchanger



The new Ross Type SSCF all-stainless steel heat exchanger is said to be the first to reach mass production, permitting immediate delivery and low unit cost because of complete standardization and stocking of all component parts. It is offered in a complete range of sizes, tested to 450 psi. It is similar in design and capacities to the Type BCF line in copper and copper alloys, the manufacturer states. Ross Heater & Mfg. Co.

2—Tank Maintenance Scaffold

Improved construction in the "Up-Right Roll-Around Safety Cage Scaffold" permits its clearing all obstacles on the top of the tank, including such usual obstructions as 42-in. guard rails. The method of suspension of the cage itself permits clearing obstacles on the tank sides such as gage boards, pipes, ladders, stairways, etc. The Roll-Around unit is fastened by a cable to the center of the tank and the cage suspended by block-and-tackle from anyone of several attaching positions, giving a distance of overhang of 18, 24, 30, 36, or 40 in. Vertical clearance is 44 in. Cage weighs 70 lbs., Roll-Around weighs 48 lbs. Load capacity is 1000 lbs., with a safety factor of 4. Up-Right Scaffolds, Inc.

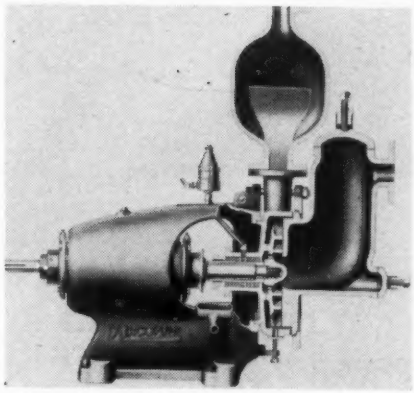


For More Information

Use one of the attached reply cards to request additional information or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the rest of the card, and drop it in the mail. No postage required.

3—Corrosives Pump

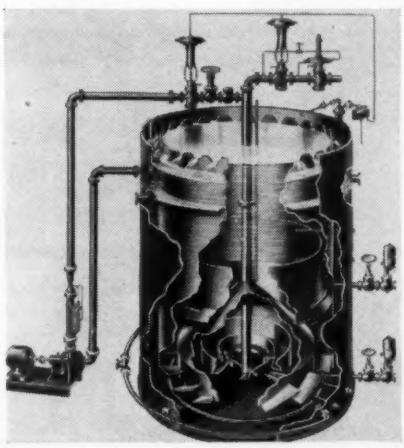
The Model 40, Series R Self-priming "Durcopump," now in regular production, is believed to be the most efficient centrifugal pump of its type ever made for handling corrosive solutions. Plant tests in accordance with Hydraulic Institute standards have shown the pumps to prime in 22 secs. with a static lift of 15 ft., and then maintain dry vacuum as high as 28.4 in. Hg. With a static lift of 10 ft., air was admitted to the suction line of a 1½ x 1½ in. pump at the rate of 54 cu. ft./min. without breaking the prime. It is available in two sizes: one with a capacity ranging from 20 gpm. against 81 ft. TDH. to 160 gpm. against 33 ft.; the other, 40 gpm. against 125 ft. to 240 gpm. against 75 ft., when operating at 1750 rpm.



It is built in most corrosion-resisting alloys and cast steel, with Teflon seal cages in stuffing boxes. The Duriron Co.

4—Cold Process Water Softener

Optimum flocculation is achieved without submerged mechanical moving parts inside the new Worthington cold process, slurry type, precipitating water softener and coagulator. The unit employs hydraulic energy to mix applied chemicals with previously formed precipitate. Complimentary recirculation of treated water maintains a uniform slurry bed depth independent of load demand on the plant. Where filters are used for final clarification, a washer reclamation compartment is incorporated to enable economical backwashing



USE STRONG* STRAINERS -for *better* protection!

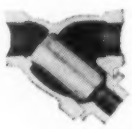
For steam, air, water and gas. STRONG'S new "Y" type strainer is ideal for the protection of steam traps, reducing valves, temperature controls, air control equipment, pumps, etc.

A HIGH-QUALITY, LOW-COST STRAINER!

★ **Monel Screen**—Mesh cloth in sizes ¼" to ⅜", larger sizes standard with .027 perforations. Self-centering guides prevent crushing.

★ **Semi-steel Body**—For rugged service. Sizes ¼" to 2". For steam pressures to 250 psi, cold pressures to 400 psi.

★ **Easy Installation**—New V-shaped gripping lugs on inlet and outlet bosses—may be easily installed with any type wrench.



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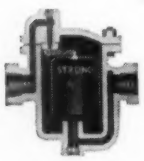
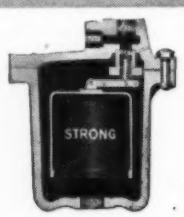


No. 070 Small Trap



80 Series Trap

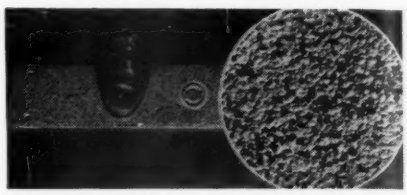
"T" Type Strainer

STRONG

What's New!

with clean, chemically inert water without increasing flow rates through the softener. The system may be applied to any condition or capacity where a clear, moderately soft effluent will meet the need; for example, cooling tower makeup, or certain phases of waste disposal. Worthington Pump & Machinery Corp.

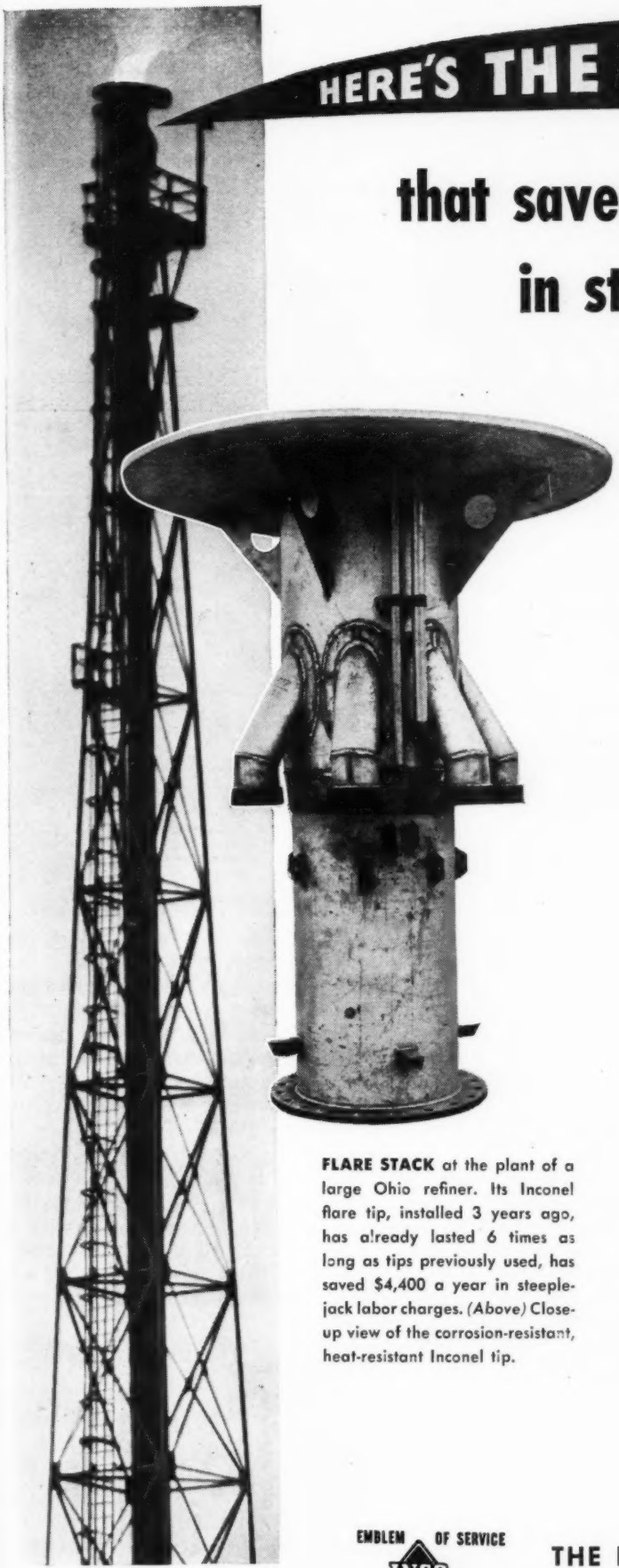
5—Safety Tread Flooring



A new low-cost, safety tread flooring material, "Perma-Tread" has been announced, made of a heavy-gage, cast aluminum plate which has a fine silica-carbide grit distributed through the casting and permanently bonded into its surface. The product is recommended for use as stair plates, and nosing, and flooring surface anywhere there is potential spillage of water, oils, and greases. It is available in various sizes up to a maximum of six ft. continuous length and one ft. width, in thicknesses of ¼, 5/16, and ⅜ in. Mold-Cast Alloy Corp.

6—Water Bath Won't Go Dry

A new portable water bath for laboratory use incorporates a special water feed device which prevents it from "boiling dry" for as long as 10 hrs. on low heat and 4 to 5 hrs. on high heat. The bath employs two electric immersion type heaters, has a Monel exterior and tinned copper interior. It measures 15 in. in diameter and 7 in. high and weighs 24 lbs. Fisher Scientific Co.



HERE'S THE TIP

that saved a refinery $13,200 in steeplejack labor!

In three years, a large Ohio refinery has saved $13,200 in steeplejack charges.

The story is told here for the first time...

Until 1946, the average life of a flare tip on the main stack at this plant was six months. By that time, the tip was ready to be taken down and replaced – at a cost of $2,200 for steeplejack labor alone!

Too much, agreed engineers, so they started looking for flare tips that would last longer. **As a result of their experimentation, steeplejack labor for flare tip maintenance and replacement on this stack has not cost a cent since 1946.**

What happened? They had a flare tip built of heat-resistant, corrosion-resistant INCONEL*. To date, it has delivered *six times the service* of the best flare tip previously used – and it's still on top of the stack, still holding out against corrosive gases, soot deposits and high temperatures.

INCONEL is regarded as one of the outstanding alloys for withstanding red-heat temperatures without scaling or cracking. Like all INCO Nickel Alloys, it has remarkable resistance to corrosion. In addition, it can be cut, bent, formed, machined and welded by ordinary shop methods. Welds are as resistant to heat and corrosion as INCONEL itself.

So think of INCONEL for refinery applications that demand a metal with exceptional resistance to corrosion and high temperatures. **And remember to turn some of your problems over to our Technical Service.** These men know what has been done (and what is being done) to provide durable metals for your kind of work.

FLARE STACK at the plant of a large Ohio refiner. Its Inconel flare tip, installed 3 years ago, has already lasted 6 times as long as tips previously used, has saved $4,400 a year in steeplejack labor charges. *(Above)* Close-up view of the corrosion-resistant, heat-resistant Inconel tip.

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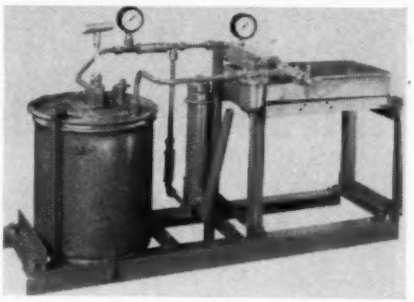
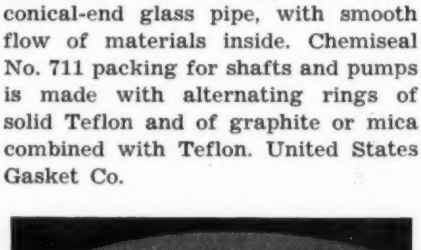
7—Hydraulic Tester



A compact hydraulic test fixture has been designed for bench mounting for checking gages, valves, piping tubing, and the like, and capable of tests up to 5000 psi. The equipment comprises a low pressure pump for quick filling of equipment under test from a reservoir holding approximately 3 gals. Higher pressure units can be supplied. J. N. Fauver Co., Inc.

8—"Teflon" Packing Gaskets

Tetrafluorethylene, "Teflon," the plastic material inert to all known chemicals up to 550° F., is now available in two new forms of packing or gasket material. "Chemiseal Snap-On" gaskets have been designed to accommodate deflecting and misalignment in assembling sections of conical-end glass pipe, with smooth flow of materials inside. Chemiseal No. 711 packing for shafts and pumps is made with alternating rings of solid Teflon and of graphite or mica combined with Teflon. United States Gasket Co.

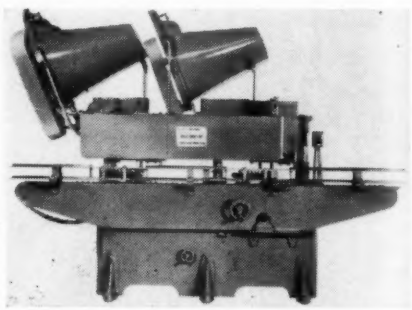


9—Deodorants for Petroleum

Development is announced of a line of materials, trade-named "Reductors," for use in the reduction of unpleasant odors in crude and refined petroleum products. The materials are not masking or covering agents but truly odor reducing agents. Their purpose is to reduce the odor to a point where only a slight identification odor remains. No special processing other than simple mixing is required for their use, it is stated. Cost is less than ⅛ of a cent per gallon of the product to which they are added, the manufacturer says. 44 Trinity Place Corp.

10—High-Speed Capping Machine

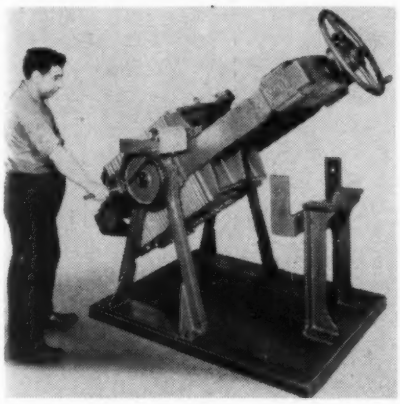
The new "Upressit-Resina" automatic capping and sealing machine, designed for applying Upressit reseal and tamper-proof over-seals, will handle all sizes of cans from half-pint to gallon. It is said to cap and seal at any rate required by the filling machine, up to a maximum of 500 per hour. Upressit Products Corp.



11—Gasket Cutter

The new "Spearhead Cutter" is an all-purpose tool, combining the functions of a circle cutter, straight edge, compass, scorer, and knife in a single manually operated device. Maker states the device will prevent thin materials from buckling or "crinkling" while being cut. Circles of diameters from ¼ to 6 in. can be cut. Weighing less than four ounces, the cutter is made of phenolic plastic, 4¼ in. long, 1¼ in. wide, ¾ in. high. It comes packaged in a kit including a cutting board, two blades, and two pivot pins, and retails for $7.50. Zimmerman Packing Co.

What's New!



12—Tilting Filter Press

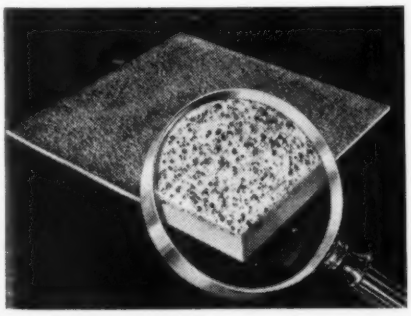
Filtration can be performed with the filtering surface in a horizontal position in a new tilt type press which allows plate cleaning in the usual vertical position. This offers the advantages of horizontal filtration, where filter aids and cake constituents may flow evenly to deposit a uniform cake over the surface which will not be disturbed should the flow of feed be cut off at any time. Yet, cleaning can be done in the normal, easy, vertical position. T. Shriver & Co., Inc.

13—Gate Valve

The new 24 in. Series 150, O. S. & Y. Kerotest gate valve has been made available, both in solid wedge Fig. 11 and split wedge Figure 319 design, with all standard trims. Operation can be hand wheel, motor, bevel gear with pinion, or sprocket and chain on pinion. Kerotest Mfg. Co.

14—Safety Floor Plate

An abrasive, rolled steel, non-skid floor plate, "A.S. ALGRIP", is now being produced by combining previously irreconcilable materials—abrasive grain and rolled steel—according to the manufacturer. It is recommended for any slipping hazard location — loading platforms, ramps, trench and hatch covers, walkways, etc. Abrasive grain of the same type



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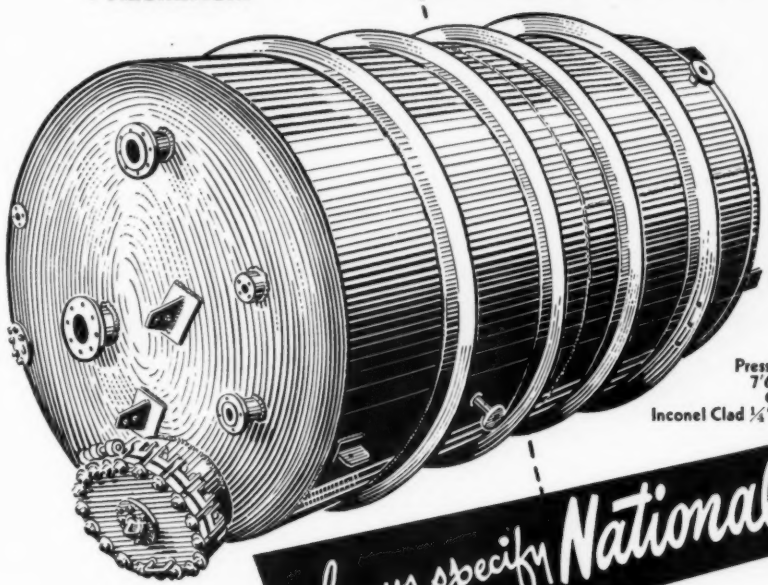

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used on grinding wheels is rolled as an integral part of the upper portion of the plate. It can be sheared, drilled, countersunk, machined, and flame-cut. Plates are available in thicknesses from ⅛ to ⅜ in., widths up to 60 in. maximum and 144 in. long. Alan Wood Steel Co.

15—Water Hardness Tester

The Betz hardness test for water analysis is said to be more accurate than the soap method and more rapid. Non-skilled personnel can run this titration method using a color indicator. Accuracy is to within 2 ppm., and over 1000 ppm. can be titrated without sample dilution. The method is based on the titration of a water sample with an organic sequestering agent—disodium dihydrogen ethylenediamine tetracetate dihydrate—which forms un-ionized complexes with calcium and magnesium. The indicator, Eriochrome black T dissolved in sodium carbonate and diluted with isopropanol, is red in the presence of calcium and magnesium ions and blue in their absence. A complete test set is priced at $18 f.o.b. Philadelphia. W. H. & L. D. Betz.

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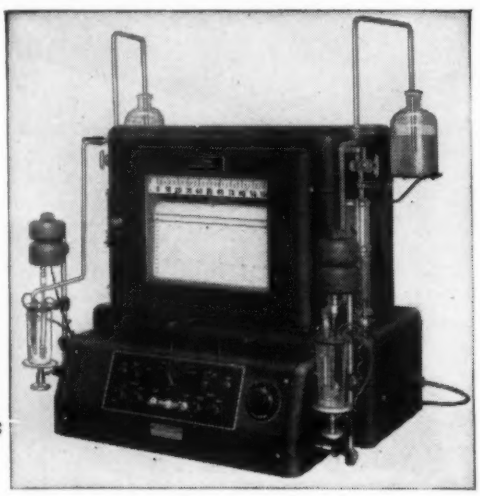

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Trade Literature

16—Evaporation Losses

Evaporation Losses from Cone Roof Tanks: second edition of a technical report, by R. C. Ulm, covering vapor concentration in cone roof tanks, breathing losses and filling losses; contains formulae for figuring vapor concentration and losses; illustrated. Graver Tank & Mfg. Co.

17—Research Instrumentation

How Sinclair Plans Tomorrow's Processes Today is a 5-page article in the current issue of *Instrumentation* (Vol. 4, No. 2), describing instrument applications in the company's new research laboratory at Harvey, Ill. Brown Instruments Division, Minneapolis-Honeywell Regulator Co.

18—Air-Blasted Concrete

"Gunite" Concrete: 28-page bulletin describing properties and uses of this material for fireproofing, insulating, waterproofing and the like; includes six pages of detailed drawings showing methods of application. Gunite Concrete and Construction Co.

19—Rotary Pumps

Pumping Viscous Materials: reprint of a paper by William E. Worcester, presented at first Pan American Engineering Congress in July, 1949, describing the application of rotary pumps to this type service. Kinney Manufacturing Co.

20—Synchronized Proportioning

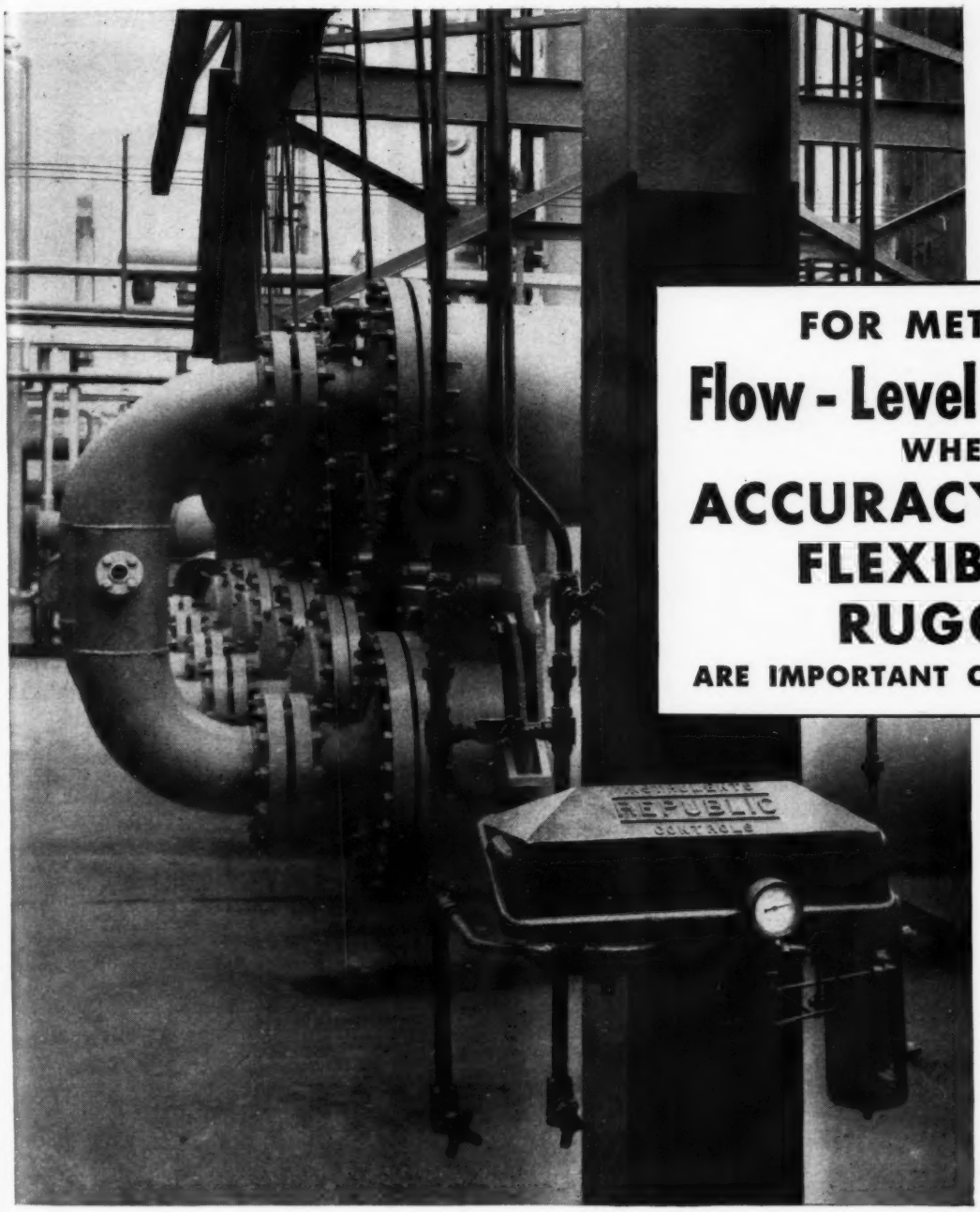
Continuous Automatic Lube Oil Blending: a 12-page technical bulletin describing the proportioning equipment and its operation, illustrated. Proportioneers, Inc.

21—Centrifugal Pumps

Pacific Centrifugal Pumps from A to Z, Bulletin 1; gives service specifications, including operating temperatures, pressures, capacities for pumps made by Pacific Pumps, Inc.

22—Combatting Corrosion

Dowell Magnesium Anodes: 16-pages describing cathodic protection, which types of anodes to use, where to locate them, and how to make the installation. Dowell, Inc.



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What's New!

23—Cleaning Refinery Equipment

Petroleum Equipment Cleaning Tasks: a series of six pamphlets devoted to (1) cleaning and descaling heat exchangers, (2) cleaning and paint stripping storage tanks, (3) cleaning tank car interiors, (4) salvage cleaning, (5) chemical-circulation cleaning of absorption, stabilizing and fractionating towers, and (6) drum washing and reconditioning. Oakite Products, Inc.

24—Hypersonic Processing

Brush Hypersonic Generator describes recent advances in the development of equipment for commercial application of ultrasonics; possible petroleum uses include blending of lube oils and greases, and "rearrangement of molecular structures." Brush Development Co.

25—Petroleum Processing Index

PETROLEUM PROCESSING *Index* for 1949: includes subject and author index for all feature articles and regular departments for the 12 issues of this magazine published during 1949; available about Jan. 5. National Petroleum Publishing Co.

26—Testing Apparatus

Petroleum Testing Apparatus, Catalog 705: 96 pages, lists and describes over 150 items of test equipment, with ASTM and other standard designations; indexed by subject and ASTM number; price list included. Precision Scientific Co.

27—Fire Extinguishers

Dry Chemical Fire Extinguishing Equipment: catalog giving descriptions and specifications for this type equipment; includes charts of comparative effectiveness of approved fire extinguishers (CO_2, foam, dry chemical) on gasoline and alcohol fires. Ansul Chemical Co.

28—Centrifugal Compressors

Commercial Application of Centrifugal Compressors and the Complementary Axial, by T. R. Foster; reprint of a paper presented before American Gas Assn., May, 1949; includes references to a number of refinery installations. Clark Bros. Co., Inc.

29—Rotary Pumps

De Laval-IMO Pumps, Catalog LG: describes six types of rotary pumps, designed to handle residual and distillate fuel oils, crude, lubes and similar viscous liquids; capacities from 0.5 to 1000 gpm. De Laval Steam Turbine Co.

30—Instrument Valves

Edward Forged Steel Instrument Valves, Bulletin 491: gives dimensions, weights, prices, operating data on new drop forged steel (carbon and stainless) valves for meter, gage, instrument and small lines. Edward Valves, Inc., subsidiary of Rockwell Manufacturing Co.

For Your Convenience

Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing page 1377. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.

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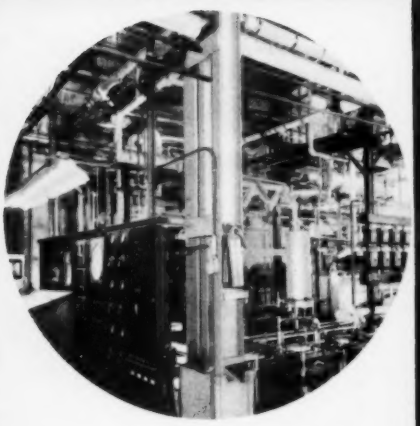
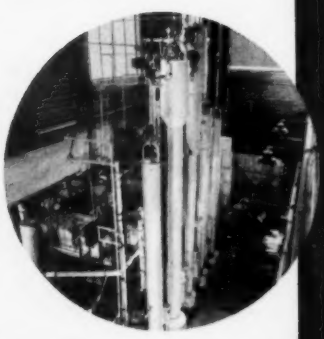
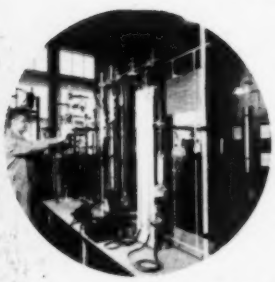
pilot plants



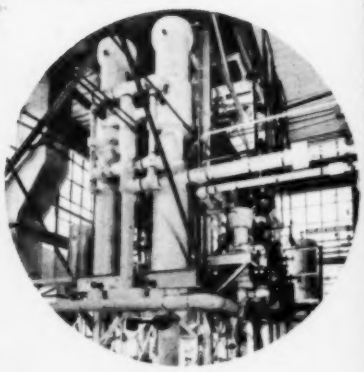
Vacuum Distillation



Precise Fractionation



Analytical Distillation



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REFINING TRENDS

"Gas" Stocks Start Winter at High Level

STOCKS of principal refined products at the end of November—start of the season to build up gasoline stocks and to draw on light and heavy fuel oil stocks—stood at the high figure of close to 290,000,000 bbls. This is nearly 8,000,000 bbls. higher than at the same time in 1948.

Gasoline stocks on Nov. 30, 1948, were around 95,500,000 bbls. and they built up to 127,400,000 bbls. by March 31, 1949. This year gasoline stocks were nearly 105,000,000 bbls. at the end of November. Rate of demand for motor fuel this year has been 5% larger than in 1948 and the rate of output of this product also has been 5% above that of 1948.

Distillate fuel stocks (including kerosine) were over 117,000,000 bbls. at the end of November this year, as compared with nearly 110,000,000 bbls. Nov. 30, 1948. Demand, domestic and export, has been nearly 9% less than for 9 months in 1948. Rate of refinery output has been below that of 1948 by about 13.7%. Severity of the weather in the coming weeks will determine the extent to which these stocks are reduced over the winter.

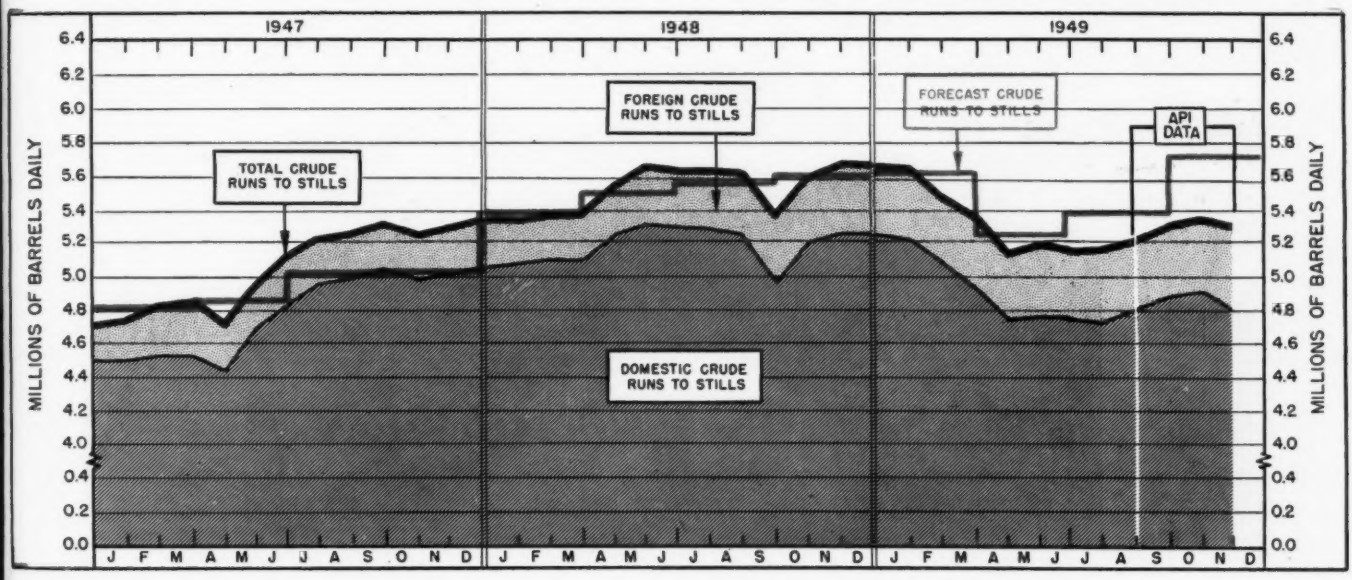
Residual fuel stocks Nov. 30, 1949, were about 67,000,000 bbls., as compared with 77,000,000 bbls. Nov. 30, 1948. Most of the decrease as shown, however, is due to a reclassification of these stocks at the start of 1949. Demand for this product has been at the rate of between 4 and 5% less than in 1949. From Nov. 30, 1948, to March 31, 1949, stocks of residual fuel oil were reduced by nearly 19,000,000 bbls., again a large share of the decrease being due to the reclassification. Refinery output of residual fuel is 10% reduced from 1948 operations.

The estimated average rate of crude runs to stills in November was 7.2% less than for November, 1948. An increased amount of imported crude was run and runs of domestic crude were down to around 4,800,000 b/d, 9% less than for the same period in 1948.

Refinery output of gasoline was still under motor fuel demand in November, Fig. 2, this relationship differing from the past two years.

The rate of refinery output of distillate fuels (including kerosine) in November was nearly 10% under that of November, 1948. For 9 months of this year the rate of put-out was 13.7% less.

Fig. 1 — Runs to Stills — Domestic Crude Dropped in November



Yields on Crude Run to Stills

(Bureau of Mines Data)

	Gasoline	Kerosine	Dist. Fuels	Res. Fuels
September, 1949, %	43.7	5.0	18.4	20.4
September, 1948, %	41.6	5.8	18.0	21.6
September, 1947, %	40.7	5.4	17.2	23.4

End-of-Month Inventories, Refinery Products, 1000 bbls

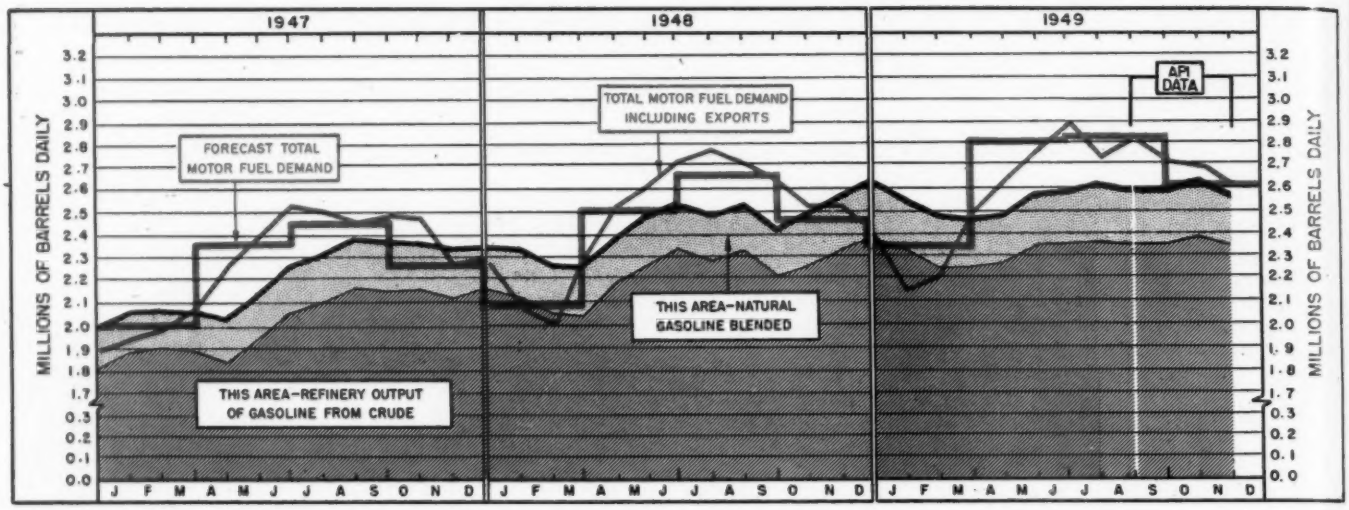
	Gasoline	Kerosine	Distillate	Residual	Total
Oct. 31, 1949 (API data)	104,013	28,275	90,838	69,400	292,526
Sept. 30, 1949 (B of M data) ...	103,850	27,115	83,200	67,981	282,146
Oct. 31, 1948 (B of M data)	92,426	26,283	82,920	72,363	273,992

U. S. Refinery Operations, bbls

	Crude Runs to Stills			Motor Fuel Supply			Distillate Production			Residuals		
	Domestic	Foreign	Total	Gasoline from Crude	Natural Blended Used Direct	Total	Kerosine	Distillate	Total	Refinery Production	Imports	Total
Nov., 1949, b/d avg.*	4,799,000	463,600	5,262,300	2,345,000	300,000	2,645,000	302,400	1,093,000	1,305,400	1,140,000	285,000**	1,425,000
Nov., 1948, b/d avg.	5,273,200	389,900	5,672,100	2,320,000	306,000	2,626,000	362,000	1,081,000	1,443,000	1,277,000	137,000	1,414,000
Change in 1949, b/d	—474,000	+64,700	—409,800	+25,000		+19,000	—59,600	—78,000	—137,600	—137,000	+148,000	+11,000
	(9%)	(16.2%)	(7.2%)	(1.1%)		(0.7%)	(16.5%)	(7.2%)	(9.7%)	(10.7%)	(108%)	(0.8%)
9 Mos., 1949, 1000 bbls.	1,338,350	111,669	1,450,019	635,313	80,045	715,358	72,785	247,635	320,420	316,774	49,003	365,777
9 Mos., 1948, 1000 bbls.	1,422,685	87,055	1,509,740	605,241	75,461	680,702	90,491	289,791	371,282	348,237	40,654	388,891
Change in 1949, 1000 bbls	—84,336	+24,614	—59,721	+30,072	+4,584	+34,656	—17,706	—33,156	—50,862	—31,463	+8,349	—23,114
	(6%)	(28.2%)	(3.9%)	(4.9%)	(6.1%)	(5.1%)	(19.5%)	(11.8%)	(13.7%)	(9.0%)	(20.5%)	(5.9%)

* Through Nov. 26, 1949 only. ** Estimated.

Fig. 2 — Motor Fuel — Supply and Demand About in Balance


1947
1948
1949
MILLIONS OF BARRELS DAILY
FORECAST TOTAL MOTOR FUEL DEMAND
TOTAL MOTOR FUEL DEMAND INCLUDING EXPORTS
API DATA
THIS AREA—NATURAL GASOLINE BLENDED
THIS AREA—REFINERY OUTPUT OF GASOLINE FROM CRUDE
J F M A M J J A S O N D

The motor fuel demand line and the forecast demand line include, in addition to refinery gasoline and natural gasoline blended at refineries, a varying volume of natural gasoline used direct as motor fuel. This volume averages around 70,000 b/d.

Fig. 3 — Gasoline Stocks — High to Start Seasonal Increase

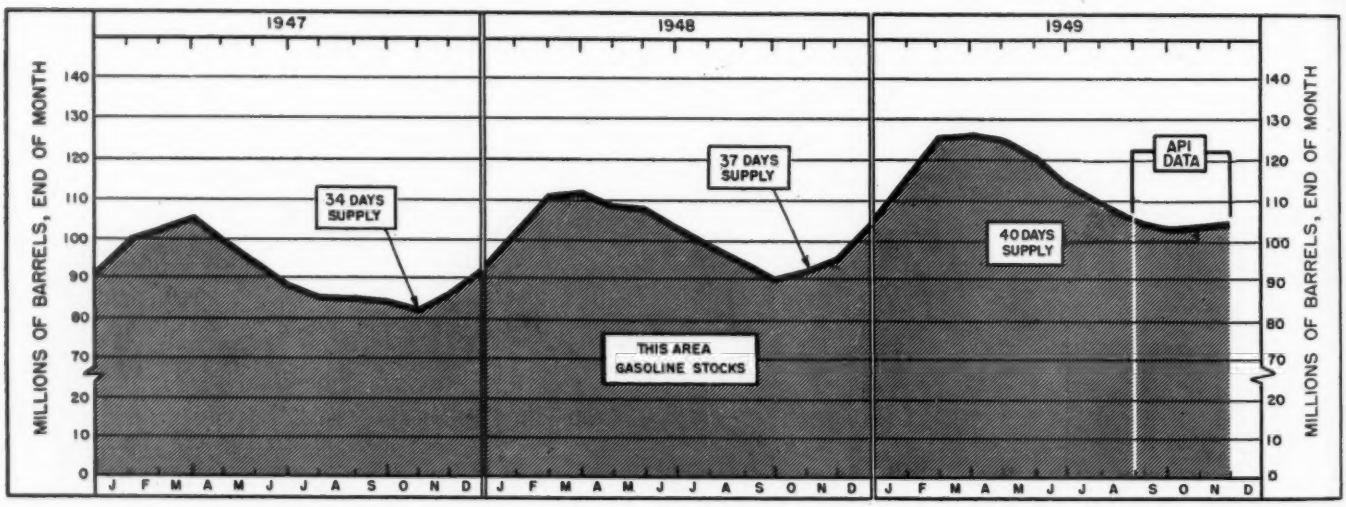


Fig. 4 — Distillate Fuels — Sharp Increase in Demand in November

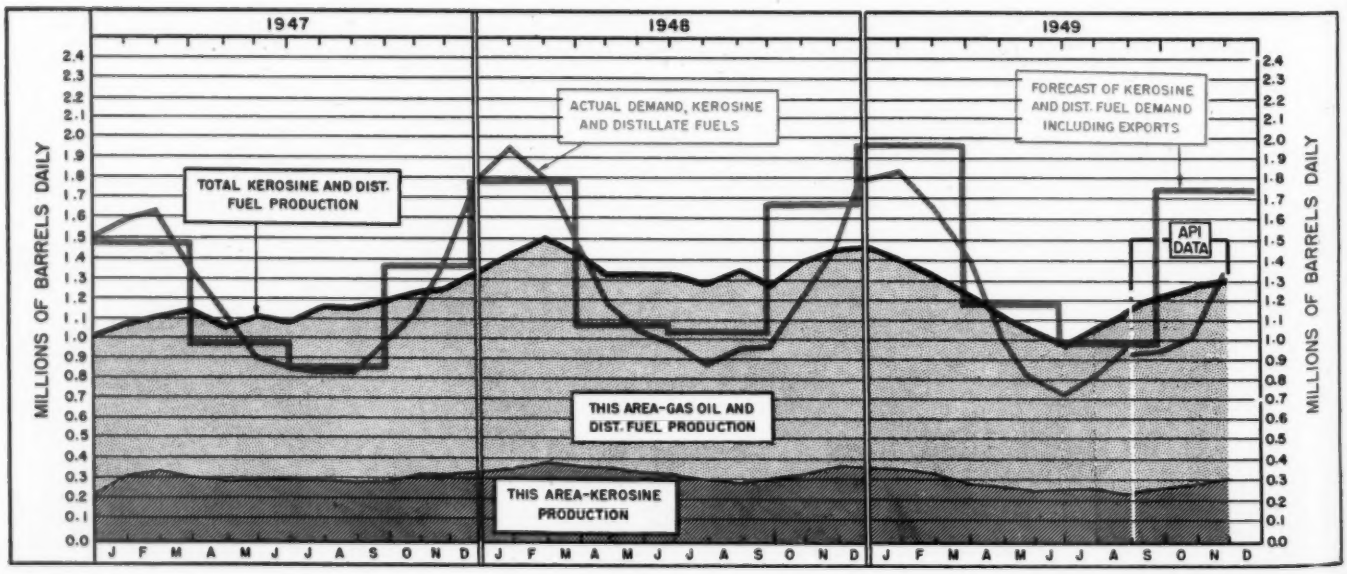
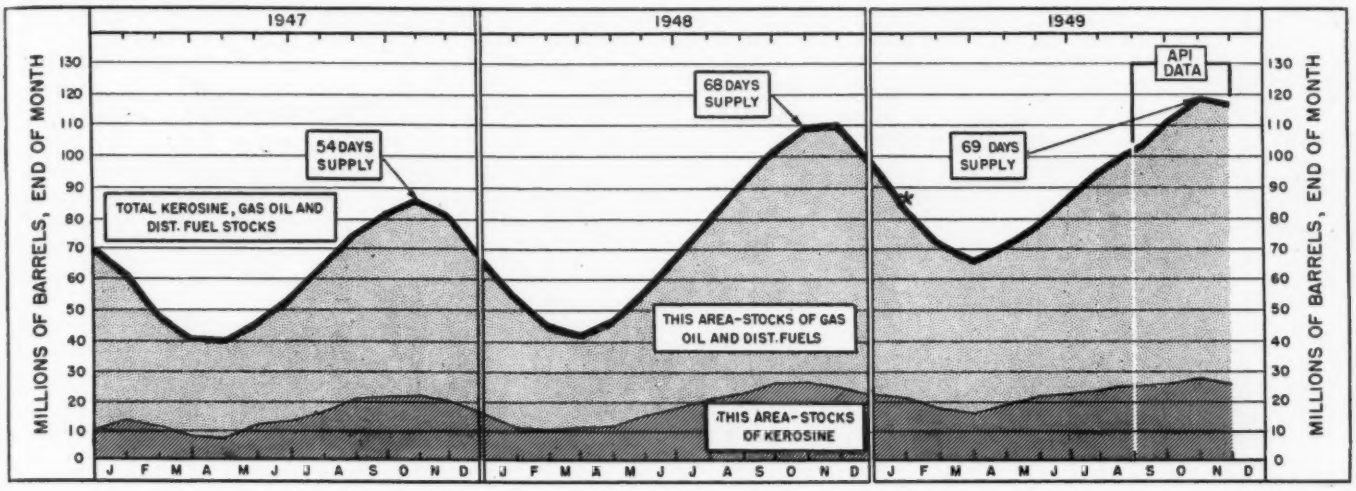

1947
1948
1949
MILLIONS OF BARRELS DAILY
TOTAL KEROSINE AND DIST. FUEL PRODUCTION
ACTUAL DEMAND, KEROSINE AND DISTILLATE FUELS
FORECAST OF KEROSINE AND DIST. FUEL DEMAND INCLUDING EXPORTS
API DATA
THIS AREA-GAS OIL AND DIST. FUEL PRODUCTION
THIS AREA-KEROSINE PRODUCTION
J F M A M J J A S O N D

Fig. 5 — Distillate Stocks — Slight Drop in Past Few Weeks


1947
1948
1949
MILLIONS OF BARRELS, END OF MONTH
54 DAYS SUPPLY
TOTAL KEROSINE, GAS OIL AND DIST. FUEL STOCKS
68 DAYS SUPPLY
THIS AREA-STOCKS OF GAS OIL AND DIST. FUELS
THIS AREA-STOCKS OF KEROSINE
69 DAYS SUPPLY
API DATA
J F M A M J J A S O N D

* About 5,000,000 bbls. of the drop in kerosine and distillate stocks shown in January, 1949, is due to a difference in reporting adopted in California, where cracking stocks were dropped from this classification.

Fig. 6 — Residuals — Demand Approaches Last Winter's Level

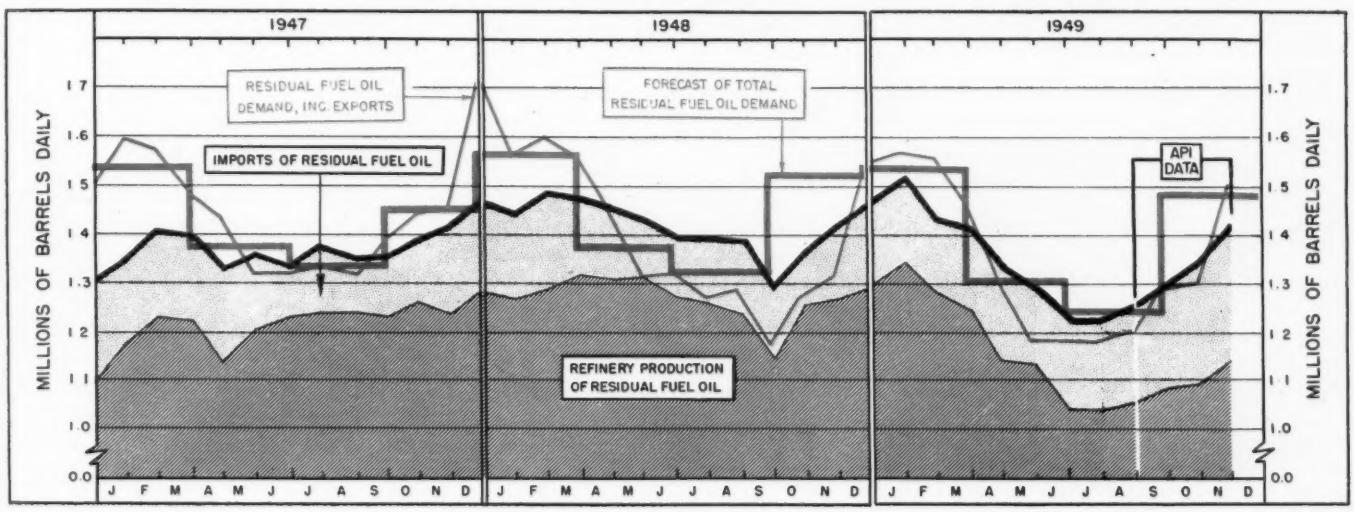
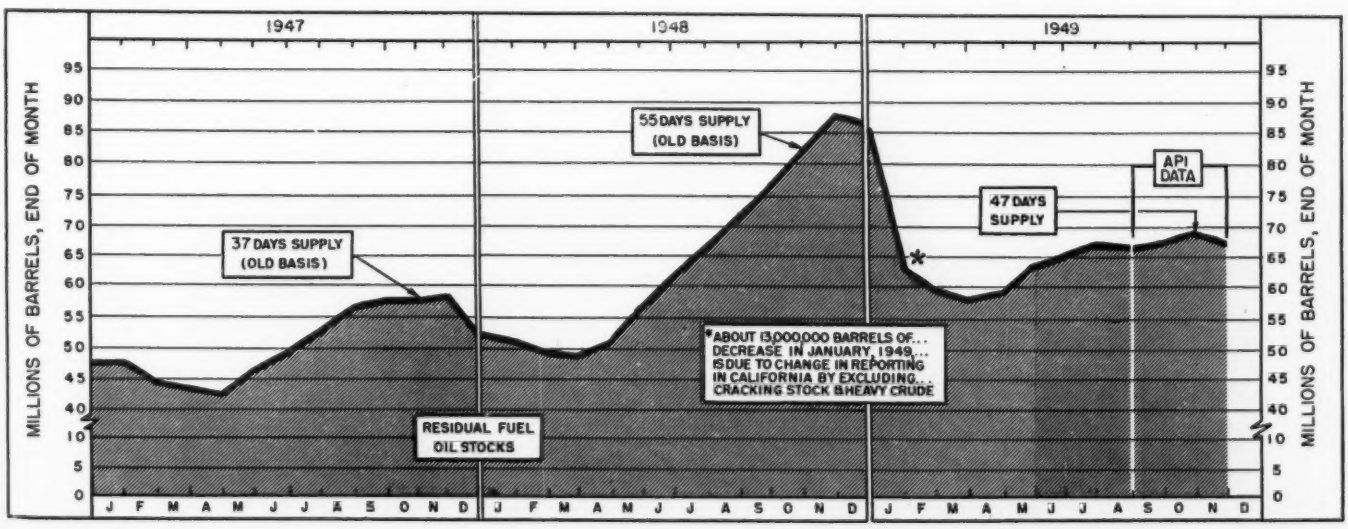

1947
1948
1949
MILLIONS OF BARRELS DAILY
RESIDUAL FUEL OIL DEMAND, INC. EXPORTS
IMPORTS OF RESIDUAL FUEL OIL
FORECAST OF TOTAL RESIDUAL FUEL OIL DEMAND
REFINERY PRODUCTION OF RESIDUAL FUEL OIL
API DATA
J F M A M J J A S O N D

Fig. 7 — Residual Stocks — Turned Downward in November


1947
1948
1949
MILLIONS OF BARRELS, END OF MONTH
37 DAYS SUPPLY (OLD BASIS)
55 DAYS SUPPLY (OLD BASIS)
47 DAYS SUPPLY
API DATA
RESIDUAL FUEL OIL STOCKS
*ABOUT 13,000,000 BARRELS OF... DECREASE IN JANUARY, 1949,... IS DUE TO CHANGE IN REPORTING IN CALIFORNIA BY EXCLUDING... CRACKING STOCK & HEAVY CRUDE
J F M A M J J A S O N D

* Residual fuel oil stocks July 31, 1949, (API data) new basis, 67,183,000 bbls. Stocks July 31, 1948, old basis, 66,262,000 bbls: July 31, 1947, 52,808,000 bbls.

Fig. 8—Production of Natural Gasoline and Production Forecast

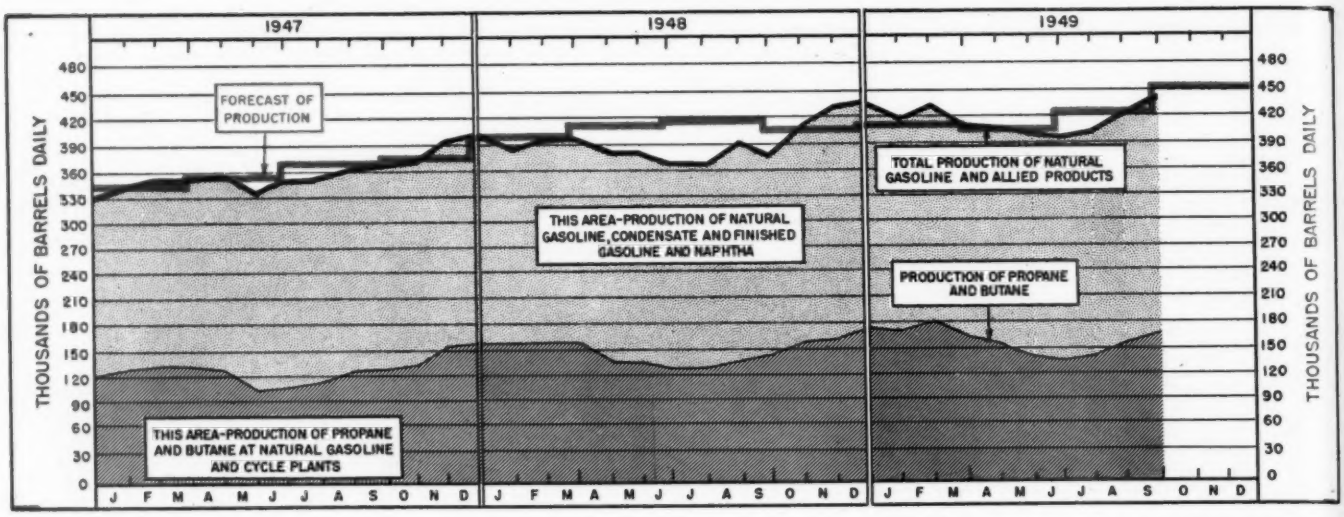
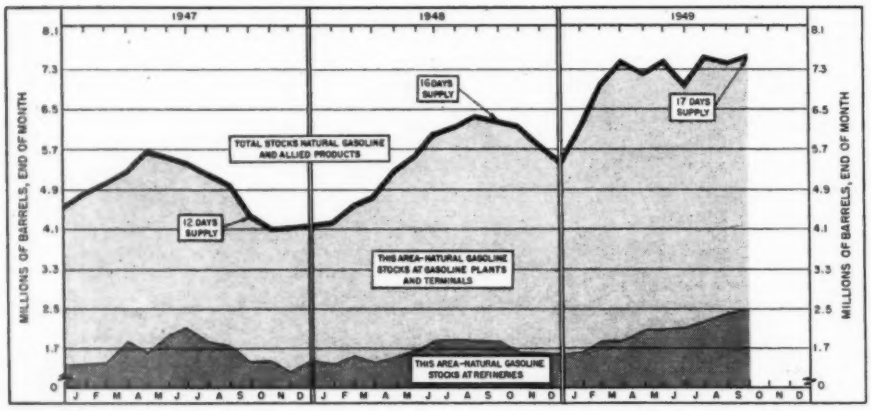

1947
1948
1949
THOUSANDS OF BARRELS DAILY
FORECAST OF PRODUCTION
THIS AREA-PRODUCTION OF PROPANE AND BUTANE AT NATURAL GASOLINE AND CYCLE PLANTS
THIS AREA-PRODUCTION OF NATURAL GASOLINE, CONDENSATE AND FINISHED GASOLINE AND NAPHTHA
TOTAL PRODUCTION OF NATURAL GASOLINE AND ALLIED PRODUCTS
PRODUCTION OF PROPANE AND BUTANE
J F M A M J J A S O N D

Fig. 9—Stocks of Natural Gasoline

(Days supply figured in terms of current demand)

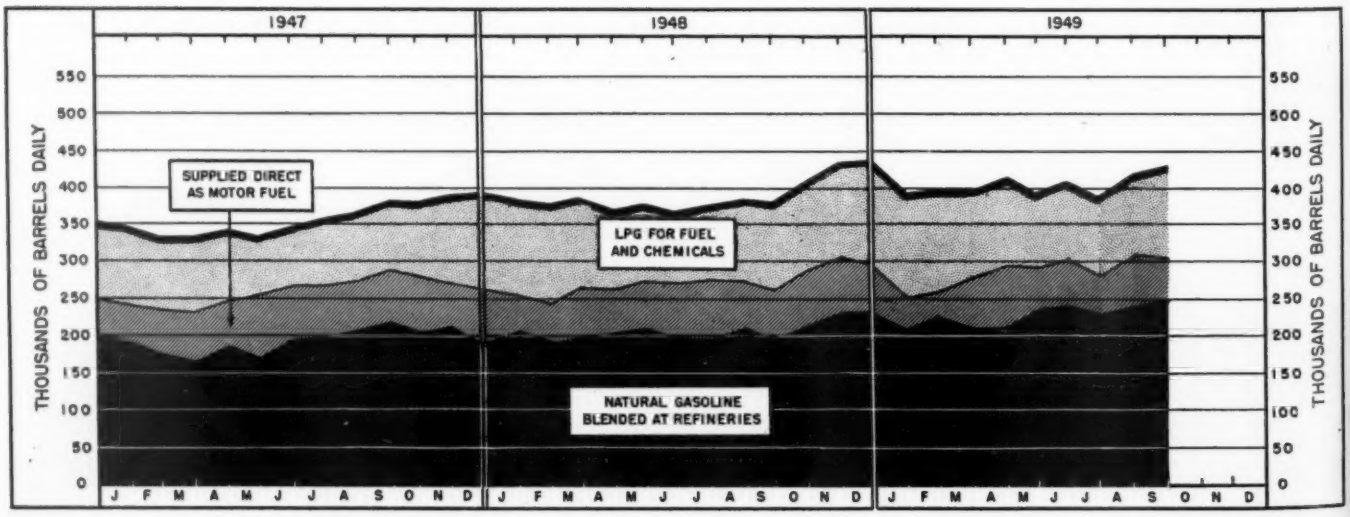

1947
1948
1949
MILLIONS OF BARRELS, END OF MONTH
TOTAL STOCKS NATURAL GASOLINE AND ALLIED PRODUCTS
12 DAYS SUPPLY
16 DAYS SUPPLY
17 DAYS SUPPLY
THIS AREA-NATURAL GASOLINE STOCKS AT GASOLINE PLANTS AND TERMINALS
THIS AREA-NATURAL GASOLINE STOCKS AT REFINERIES
J F M A M J J A S O N D

Natural Gasoline Statistics

(Bureau of Mines Data)

	Propane & Butane	Heavier Naturals	Total
	—Production, b/d, avg.—		
September, 1949 ...	166,000	276,000	442,000
September, 1948 ...	145,000	239,000	384,000
Change in 1949....	+21,000 (14.5%)	+37,000 (15.5%)	+58,000 (15.1%)
	—Total Production, 1000 Bbls.—		
9 Months, 1949.....	42,420	70,933	113,353
9 Months, 1948.....	38,745	67,593	106,338
Change in 1949.....	+3,675 (9.4%)	+3,340 (4.9%)	+7,015 (6.6%)
	—Principal Demand b/d avg.—		
	Blended at Refineries	Supplied Direct as Motor Fuel	LPG for Fuel & Chemicals
September, 1949 ...	249,000	53,000	127,000
September, 1948 ...	198,000	67,000	114,000
Change in 1949.....	+51,000 (25.7%)	—14,000 (20.8%)	+13,000 (11.4%)
	—Total Demand, 1000 Bbls.—		
9 Months, 1949.....	62,382	15,635	31,613
9 Months, 1948.....	55,524	17,946	29,790
Change in 1949.....	+6,858 (12.3%)	—2,311 (12.8%)	+1,823 (6.0%)
	Stocks, End of Month 1000 Bbls.		
	Refineries	Gasoline Plants	Total
August, 1949	2,500	5,107	7,607
August, 1948	1,817	4,470	6,287
Change in 1949.....	+683 (37.6%)	+637 (14.3%)	+1,320 (20.9%)

Fig. 10—Principal Demand for Natural Gasoline


1947
1948
1949
THOUSANDS OF BARRELS DAILY
SUPPLIED DIRECT AS MOTOR FUEL
LPG FOR FUEL AND CHEMICALS
NATURAL GASOLINE BLENDED AT REFINERIES
J F M A M J J A S O N D

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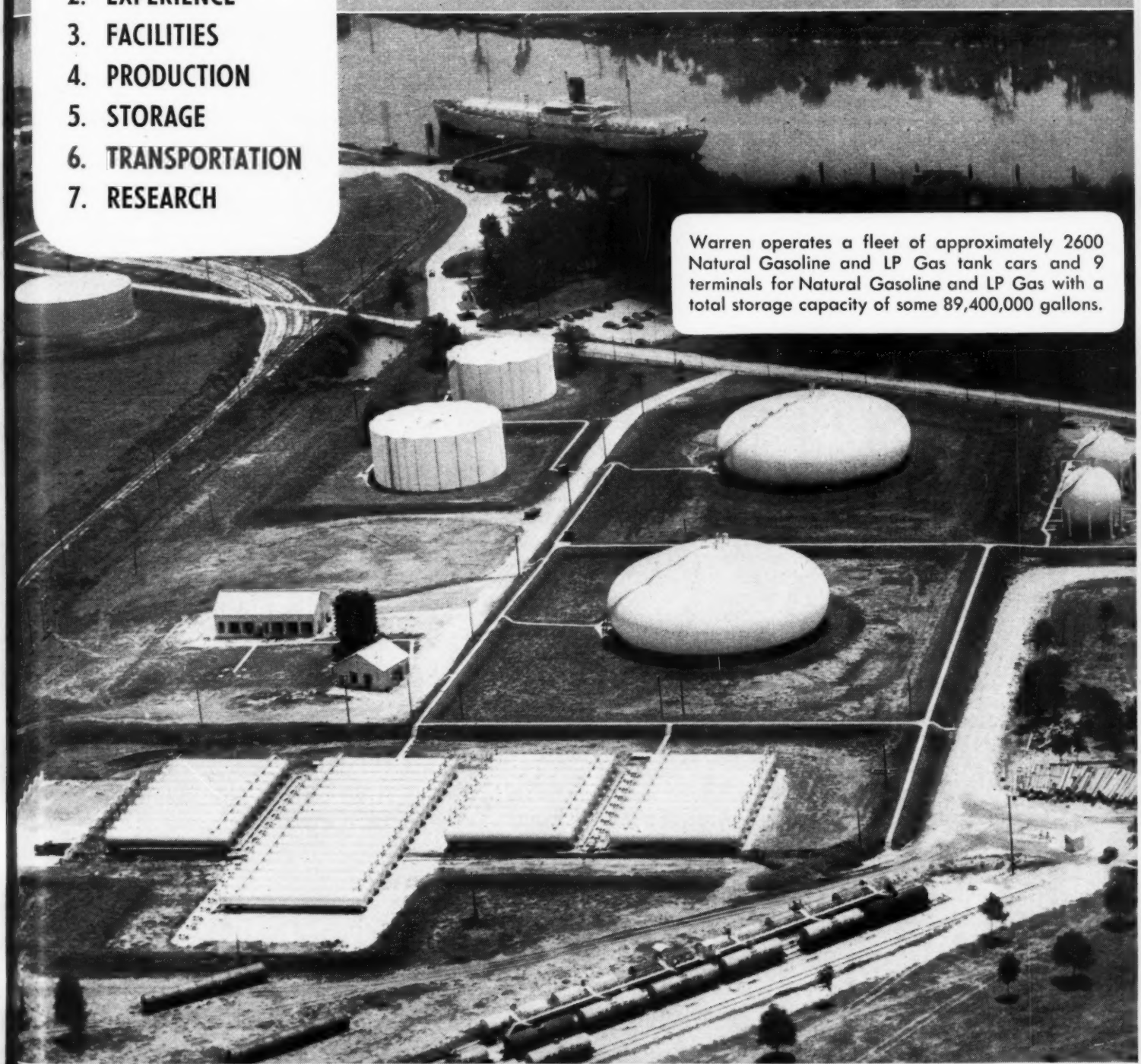

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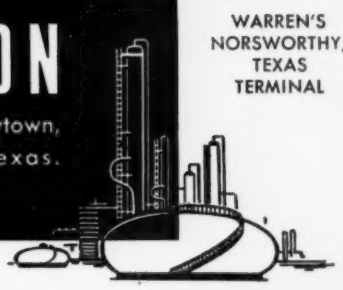

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Gasoline and Cycling Plant Operation

Conducted by DAVE THORNTON

The practical data on gasoline plant operating problems given in this department this month is taken from papers and discussions presented at the Southern Regional Meeting of the Natural Gasoline Assn. of America, at Tyler, Texas, Oct. 14. The questions selected concern problems which are common to many plant operators.

As always, questions from readers are invited pertaining to the above or other features of gasoline and cycle plant operation

Points to Keep in Mind In Compressor Lubrication

Discuss the general factors affecting proper lubrication of gas and air compressors? What may be done to prevent carbon deposition on packing, rods and valves, as well as scoring?

We claim no authority to discuss lubrication problems to the extent of recommending a specific lubricant for a special condition. Experience has shown the following contribute to the problems encountered in lubricating cylinders and piston rod packing: (1) operating compression ratio; (2) cylinder operating pressure, (3) jacket water temperature, (4) type of gas handled, (5) single or multistage operation, (6) dirt and contamination in gas, (7) adequacy of maintenance.

The compression ratio determines the gas discharge temperature and the differential pressure across piston rings and packing rings. If low, discharge temperature and differential pressure will be low. With a dry, sweet gas there is little lubrication problem, since with a low discharge temperature there is little likelihoood of hard deposits forming on valves and the oil need not have high film strength to seal the pressure. An SAE 30 or 40 oil without additives may be used, or the same oil as in the engine crankcase.

Oil having a high film strength and minimum of carbon residue must be chosen when the compression ratio is high, giving high discharge temperatures and pressure differentials. The high temperature naturally decreases oil viscosity, therefore requiring a higher viscosity. Should a discharge valve stick or break, cylinder temperature will increase markedly and, if on the crank end of the cylinder, there is a possibility that a carbon deposit will form on the hot, uncooled piston rod or the packing. Too, the extra heat may break down the lubricant on the cylinder, giving rise to blow-by and ultimately scoring.

Increasing discharge pressures requires higher film strength in the oil, else blow-by and scoring will result. Low pressure cylinders always are much larger than high-pressure cylinders, requiring additional oil feeds for proper lubricant distribution. It is advisable to use a light oil in low pressure cylinders to simplify the distribution problem and reduce drag.

Use a heavier oil if pressures are increased and if above 2000 psi. Viscosity will be reduced when hydrocarbons are compressed to high pressures because the gas tends to go into solution in the oil and this must be compensated for. Table 1 shows this effect for an oil saturated with natural gas at high pressures.

Adding neutral fatty oils to lubricants for high pressure cylinders has proven satisfactory in the field. Cylinders of 5 to 6 in. diameter operating at 4500 psig. have been successfully lubricated with oil having viscosities from 160 to 260 Saybolt Universal at 210° F.; somewhat lighter oils, compounded with 5 to 15% neutral tallow or lard oil, also have been used. Some cycling plants, however, have reported sand plugging when such lubricating oils were used but this does not seem to be a general rule.

Increasing jacket water temperature may minimize lubrication problems when handling a wet gas, or one saturated with moisture. When the wall is cooler, liquid is likely to condense, washing the oil from the cylinder or thinning it. Keeping the wall at a relatively high temperature minimizes condensation, although a higher viscosity oil may be necessary to compensate for the temperature effect.

Increasing wall temperature will not work if the gas contains liquid slugs. If the liquid is water, it is advisable to use an oil which will emulsify with oil rather than be washed off. A water-in-oil emulsion is much better than oil drops suspended in water.

The type of gas pumped will affect the lubricant if it contains H_2S, moisture, hydrocarbon liquids, oxygen in large proportion, chlorine, or chemically active gases. For H_2S or constituents tending to wash the oil from the walls, flooding with mineral seal oil is a useful expedient, or compounding with rapeseed oil or tallow oil. Petroleum oil cannot be used to lubricate compressors handling oxygen, which forms an explosive combination with the usual petroleum products. Chlorine forms gummy sludges and deposits. When sludging or deposits form with a supposedly inert gas, chemical analysis of gas and sludge should be made promptly.

Lubrication of the first stage cylinder of a multistage compressor may be treated as for a single-stage machine. The second and subsequent stages may give trouble if liquids condensed from the gas in the intercoolers are not removed. Otherwise, entering under high pressure, the slugs or drops will have high enough velocities to remove lubricant from cylinder walls and piston rod by impact alone. Such coolers should be equipped with adequate separators and drains and, in general, velocities through liquid knockout drums should be well below 1 ft. per second to avoid liquid carryover.

Dirt in a gas creates a compressor

TABLE 1—Viscosity Reduction Due to Dissolved Natural Gas

Oil Sample	Saybolt Viscosity 100° F.	Saybolt Viscosity 210° F.	Ratio absolute viscosity at atmospheric pressure to that at 3000 psig. 85° F.	120° F.	154° F.	180° F.
Commercial SAE 30	519	67	11.6	5.1	3.5	2.8
Bright stock	2975	165		8.7	4.1	3.9
Refined castor oil	1370	105		2.4	2.0	1.8

cylinder problem which cannot be corrected by any lubricant. Hard particles abrade cylinder surfaces and interfere with ring and valve seating; some contaminants may promote oil oxidation or decomposition; others adhere to oil-wet surfaces and build up deposits in packing rings, valves and discharge passages. Often so-called carbon deposits are largely composed of contaminants brought in with the gas. Sulfide-rich gases generally form a black, dense deposit which looks like carbon. If these cannot be removed by suitable scrubbers and cleaners, it is essential to install a flushing system to wash away any deposits which may tend to form.

Proper maintenance and operation will solve many compressor "lubrication problems." Pressure and temperature gages in suction and discharge lines, with a good daily reading record, often will indicate mechanical troubles which otherwise may be erroneously attributed to the lubricant. When new piston rings and packing are installed, they should be flooded with oil and well broken in before full pressure is applied to the cylinder.

When new packing is installed, the piston rod should be well swabbed with oil. During breaking-in, oil should be scraped from the rod as it accumulates and examined for traces of metallic powder which is always prevalent until the rings are fully seated. Pressure should be applied slowly and under no circumstances should full pressure be placed on the cylinder until all traces of these metallic powders are gone and the oil is clear.

The question of how much oil to use in lubricating a compressor cylinder is often asked. A safe value is about 1 pt. of oil per 2,000,000 sq. ft. of surface swept per day for a cylinder handling dry, sweet gas at moderate compression ratios. This quantity should be decreased slightly for large cylinders and increased slightly for small ones. An excellent test is to remove a valve and feel the cylinder wall. If dry, more oil is needed; if pools of oil are observed on the bottom of the cylinder or in the discharge passage, the oil rate may be reduced.

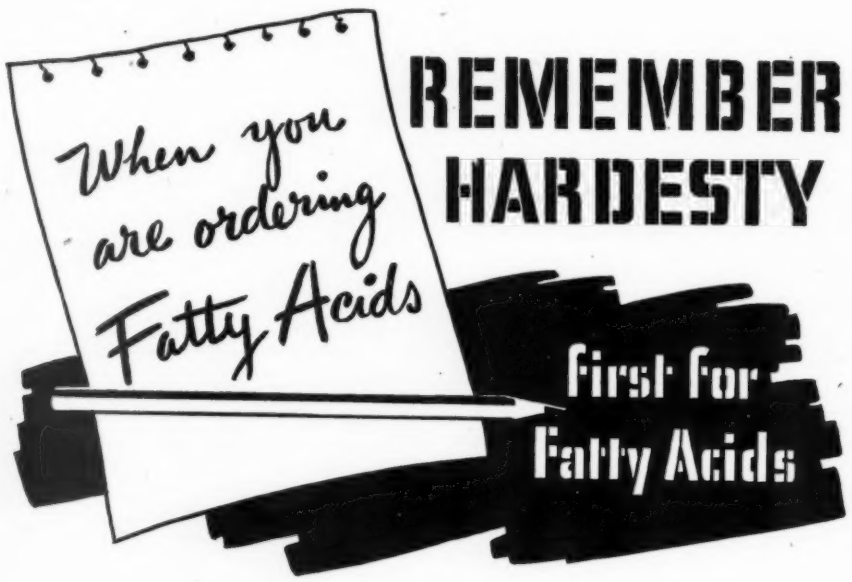
In the solution of most special lubrication problems, actual trial of a given lubricant is much more important than specifying a set of numbers which are fundamentally manufacturer's specifications and which often have little connection with the ability of an oil to lubricate a given surface adequately or remain stable under adverse conditions. Viscosity is the most important specification; color, carbon residue, and viscosity index are of little value unless the nature of the base stock, extent of refining, and additives used are also known.—F. M. McNall and E. H. Flaherty, Clark Bros. Co., Inc., Olean, N. Y.

Tips for Cooling Tower Preventive Maintenance

What are your recommendations for cooling tower maintenance?

A frequent cause of poor tower performance is accumulation of trash in the distribution system. An occasional cleaning is required. Open troughs generally are preferred because they are easy to clean. Spray nozzles should be readily removable for cleaning or replacement.

While California redwood will last almost indefinitely in water, delignification will occur if the pH value exceeds 8.5 and water preferably should be maintained near pH7. Unfortunately, the effect the treated water may have on redwood is frequently overlooked. It is sometimes desirable to supplement treatment with sulfuric acid to reduce delignification, which can be very rapid in



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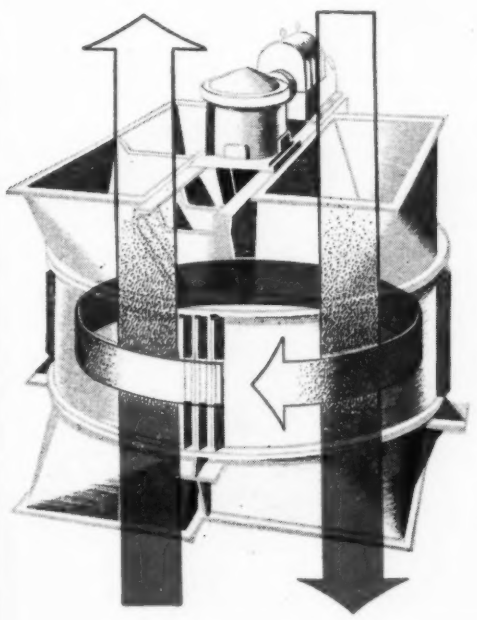

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Questions and Answers

alkaline water. Algae can be easily controlled with chlorine treatment.

Redwood is soft and therefore difficult to hold with nails. Exterior boards should be inspected and renailed with copper nails as necessary. The interior filling should be maintained in good condition; yearly attention will be cheap but profitable. If galvanized bolts and washers were used in construction, they should be replaced with brass when corrosion starts. An annual inspection of all castings and bolting is recommended.

To avoid an accumulation of scale on tower parts, a constant controlled blowdown is desirable to maintain total solids below 1000 ppm., permanent hardness below 200 ppm. A complete cleaning of the tower every year is advisable.

Most induced draft towers are equipped with a right-angle speed reduction gear. These usually depend on splash lubrication; it is very essential that the oil level be maintained within close limits. Generally the proper level is midway of the shaft on horizontally driven units.

The most frequent cause of gear failure is bearing failure. Periodic inspection with particular attention to unusual noise or vibration usually prevents expensive repairs.

The next most frequent trouble results from long shutdowns, as in winter. The recommended precaution is to drain the gearbox and refill to the top, submerging all parts in oil to prevent corrosion. It is necessary to drain down to the proper level before starting up, however. Another method is to operate the gear a few minutes daily.

The cooling tower drive usually is connected to the gear box with a torque tube and flexible couplings, all carefully aligned and dynamically balanced when installed. Carbon steel shafts should receive a protective coating yearly. Lubricated flexible couplings should be checked frequently and properly lubricated Alignment should be checked per manufacturer's instructions at least every six months, for unbalance in the drive may cause excessive vibration in the fan assembly with severe damage if not quickly remedied.

Likewise, careful alignment between driver and gear box is important. Where steam turbines are used as drivers, it is important to check the speed at regular intervals to be sure the fan is not operated beyond its speed rating.

Efficiency of the fan depends greatly upon close tip clearance between the end of the blade and the fan ring surrounding it. The ring must be round and uniform clearance maintained throughout the entire circumference.—Neal B. LauBach, Cooling Tower Division, Hudson Engineering Co., Houston.

COCHRANE RAPID REACTORS

PROVIDING THOROUGH HIGH SPEED WATER CONDITIONING at the Paulsboro Refinery of Socony-Vacuum

Increased production is the keynote for the petroleum industry these days, and typical of the industry's efforts to get this increased production is the expansion and modernization program just completed at the Paulsboro, N. J. refinery of the Socony-Vacuum Oil Company, Inc. Naturally this modernization comprises the last word in modern equipment to insure consistently high production —including Cochrane Rapid Reactors for the treatment of one of the most vital raw materials—water.

Water for use in the refining processes at Paulsboro is drawn directly from the Delaware River and introduced into the Cochrane Rapid Reactors in a raw state. The raw water is combined with chemical reagents and preformed precipitates—thoroughly agitated, and passed into an integral settling and thickening reservoir where it is collected for further treatment. Consistent with the quickened pace of this modern refinery, the Rapid Reactor completes all four of the major water conditioning operations, and does them more efficiently, in a fraction of the time required by other cold process softening methods.

Speed and efficiency are but two of the advantages of Cochrane Rapid Reactors. Original cost is low because of the simple compact design. Operating costs are held to a minimum—a saving effected by more efficient use of chemicals. Water treatment is thorough and consistent because of large recirculation volume, automatic chemical feed and sludge blowoff, and thorough mixing. The Rapid Reactor is conservative in requirements for valuable space because of its high liquid velocities.

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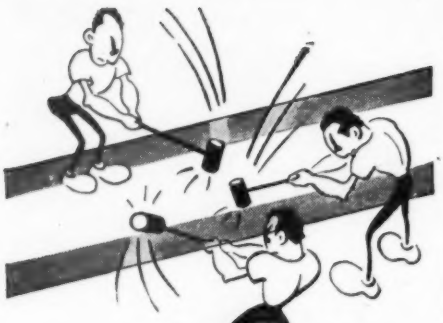

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Personals

K. O. Stowell has been made plant manager at the Cushing, Okla., refinery of Deep Rock Oil Corp., succeeding acting manager **George Waltershausen,** who has retired but will continue to serve Deep Rock as a consultant.

Mr. Stowell was formerly superintendent of Bay Petroleum Corp.'s Chalmette, La., refinery. He received his degree in chemical engineering from the University of Colorado in 1930 and then became associated with Humble Oil & Refining Co. at Baytown, Texas. He became head of the technical service group of Humble's Ingleside refinery in 1935, and later was appointed superintendent of the company's butadiene plant. In 1944 he moved to Corpus Christi to work as assistant superintendent of the Great Southern Corp. refinery until he joined Bay.

Mr. Stowell

Mr. Waltershausen

A Deep Rock employe for 29 years, Mr. Waltershausen worked for Standard Asphalt and Rubber Co. after graduation from business college in Chicago in 1907. He joined Deep Rock in 1920 as bookkeeper and stenographer, rose to superintendent, and has served as acting manager since the retirement of former vice president W. E. Moody in June.

A number of other new appointments to Deep Rock's Cushing staff have also been announced by W. J. Carthaus, vice president in charge of manufacturing and research, as follows:

New assistant chief engineer is **J. F. McDonald,** who received his B. S. degree in petroleum engineering in 1941 and M.S. degree in 1947, both from the University of Tulsa. He has worked for Trinidad Leaseholds, Ltd., Foster-Wheeler, Ltd., and Phillips Petroleum Co., and served as chief engineer with Texas Natural Gas Corp. before joining Deep Rock.

Quentin Benedict, new supervisor of distillation and treating, obtained his B.S. degree in chemical engineering from the University of Cincinnati in 1942, and took two years' extension work at Pennsylvania State College before joining Ashland Oil and Refining Co., where he has been shift superintendent the past four years.

Coming to Deep Rock from an assistant superintendent's position with Rock Island Refining Corp. at Indianapolis, Ind., **Raymond E. Feasel,** supervisor of cracking, was with Kanotex Refining Co. for 18 years and worked for Republic Oil Refining Co. at Texas City four years before joining Rock Island in 1947.

Robert Forsman was graduated from the University of Tulsa in 1942 with a B.S. degree in petroleum engineering, and started with Ingersoll-Rand Co. Later he worked for Oklahoma Natural Gas Co., Stanolind Oil Purchasing Co., and Frank Wheatley, Jr., before joining Deep Rock as supervisor of maintenance and shops.

New supervisor of products handling is **Everett W. Hubbard, Jr.,** who joined Deep Rock a year ago after receiving a degree in industrial engineering from Oklahoma A. and M. College. He served as a pilot in the Army Air Forces during the war after working for Seims Drake Construction Co. in Alaska in 1942.

Wilson Bentley fills the newly-created position of industrial engineer which will include personnel training, plant sanitation, plant safety, and new methods. He received a degree in industrial engineering from Oklahoma A. and M. College in 1939, and worked a year for Midwest Construction Co. After spending five years in the Army Corps of Engineers, he joined Wilson Packing Co. as industrial engineer in 1945. He returned to Oklahoma A. and M. in 1948 as assistant professor of industrial engineering.

* * *

Fred Denig, vice president, is manager of the Production Dept. of Koppers Co., Inc., succeeding **Hugh C. Minton,** who resigned because of ill health. He took an active part in planning and building the Koppers wartime styrene and butadiene plant at Kobuta, Pa., and the U. S. Bureau of Mines demonstration coal-from-oil plant at Louisiana, Mo.

Dr. G. Frank D'Alelio has been made vice president and manager of the Research Dept. of Koppers, the position formerly held by Fred Denig. A graduate of Boston College with a Ph. D. in organic chemistry from Johns Hopkins, he is a leading authority on plastics, coming to Koppers in 1947 after a wide experience in the plastics field.

Dr. A. R. Powell, assistant manager of the Koppers Research Dept., has

been made associate manager. He joined the company in 1923 after four years of research on coal, gas and other fuels for the U. S. Bureau of Mines. He served on the Technical Mission to Germany for the U. S. Army.

* * *

Richard E. Taylor is now asst. plant superintendent at the Worland gasoline plant, Worland, Wyo., of Pure Oil Co. He was previously with the company at Charleston, W. Va.

* * *

James E. Connor, Jr., and **Robert C. Hicks** are two new additions to the research and development department of Atlantic Refining Co., Philadelphia.

* * *

Edward F. Everett, Jr., has joined Houdry Process Corp. as a senior process engineer. He comes to Houdry from the Marshall-Morman Development Co. of New York, where he was engaged for several years as a process engineer. Prior to that he was with M. W. Kellogg Co., also as a process engineer, for ten years.

Mr. Everett

Mr. Everett played an active part in the wartime butadiene program, and has been associated with the development of hydroforming, both for war and peace-time application in the petroleum industry.

* * *

E. R. Wagner, formerly plant superintendent at the Slaughter gasoline plant of Stanolind Oil and Gas Co. at Sundown, Tex., has been transferred to the North Cowden gasoline plant at Odessa, Tex., as superintendent. He will head the new plant office which Stanolind has established to serve the North Cowden plant.

* * *

Kenneth E. Kingman has been appointed manager of manufacturing for Union Oil Co. of California, and **Elmer B. Palmer** has been named manager of the company's Wilmington refinery, the position formerly held by Mr. Kingman.

Mr. Kingman joined Union Oil in 1929 as a research chemist following graduation from the California Institute of Technology. In 1937 he became asst. superintendent of lube treating at the Oleum refinery, and finally manager of the Wilmington refinery in 1945.

Mr. Palmer was graduated in chemistry from the University of Southern California in 1920, and became associated with Union Oil as a laboratory inspector. He held a succession of positions leading to his appointment as asst. refinery manager early this year.

* * *

Charles E. Borgstrand, process superintendent for Esso Standard Oil Co. at Bayonne, N. J., has been loaned to the affiliated Vacuum Oil Co. Pty., to assist in the construction of a refinery at Altona, Australia.

* * *

C. T. Taylor is now asst. refinery manager at the Moose Jaw, Sask., refinery of British American Oil Co. He previously was master mechanic and process foreman.

* * *

W. F. Sims, for 25 years manager of the refining division of Panhandle Producing & Refining Co., has retired. Before going with Panhandle at Wichita Falls, Texas, he was with Universal Oil Products Co. in Chicago. He has been a member of the American Petroleum Institute for 25 years, and served on its board of councillors and on the general comittee of the Division of Refining. He is also a member of the board of directors of the Western Petroleum Refiners Assn.

* * *

A. W. Worrall, formerly with Houdry Process Corp., has been named assistant works manager of the Curtis Bay plant of Davison Chemical Corp., Baltimore.

* * *

Ira G. Dillon has left Sinclair Refining Co. and is now on the staff of the chemical engineering division of Argonne National Laboratory, Chicago, as an associate chemical engineer.

* * *

R. D. Waterman has been appointed executive vice president of E. B. Badger & Sons Co. Mr. Waterman has been associated with Badger since 1939, in charge of all construction activities. Prior to that he was with Stone & Webster Engineering Corp. for 25 years.

Three new vice presidents of the company have also been named: **A. J. Broggini,** vice president and sales manager, in charge of foreign and domestic sales; **A. J. Connell,** vice president and engineering manager, in charge of all engineering, drafting, estimating and procurement; **A. J. Good,** vice president in charge of office management, contracts, and engineering and construction cost analysis.

* * *

Edward L. Bryant has been appointed head of the design and economics-studies groups in the technical department at Esso Standard Oil Co.'s Baltimore refinery.

* * *

Eugene Aristoff has joined the staff of Atlantic Refining Co. in the refining research division in Philadelphia. He recently completed work on his Ph.D. at Northwestern University.

* * *

Garrett M. Crotty is now foreman in the oil-conservation department at the Bayonne, N. J., refinery of Esso Standard Oil Co., replacing **Robert G. Klose,** who has retired.

* * *

F. E. Thompson has been appointed safety engineer for Warren Petroleum Corp., and will direct the corporation's entire safety program. He comes to Tulsa after several years as superintendent of various plants built and operated by Warren.

Mr. Thompson

Starting as a field man in Brown county, Tex., in 1928, he was advanced through various positions until he was named superintendent of the Fry gasoline plant in Brown county in 1933. Six years later he was transferred to Warren's new natural gaso-

"Fuels of Future" Reprints

Because of the wide interest shown in the section on "Fuels of the Future" in PETROLEUM PROCESSING for November, pps. 1221-1244, this material has been made available in a convenient reprint form. Much valuable information and statistical data blueprinting the petroleum industry's future supply and demand requirements is contained in the papers presented at the "Fuels of the Future" session at the recent annual meeting of the American Petroleum Institute in Chicago, contained in this reprint:

"Liquid Fuel Supplies and National Security," by Walter G. Whitman; complete text.

"Fuels — Their Present and Future Utilization," by W. M. Holaday and associates; complete text, illustrations, and appendix.

"Effects on Refinery Operations of Increase in Seasonals in Petroleum Product Demands," by Courtney C. Brown; complete text and charts.

Price of the "Fuels of the Future" Reprint, including all three papers . . . 50 cents per copy. Address orders, with remittance, to Editor, PETROLEUM PROCESSING, 1213 West Third St., Cleveland 13, Ohio.

line plant at Fairbanks, Tex., serving as superintendent there for a year before being selected superintendent of a new plant at Salem, Ill. Following construction of the corporation's plant in the Cumberland field near Madill, Okla., Mr. Thompson was named superintendent in 1943, and remained there until his recent transfer to Tulsa.

George Ford succeeds Thompson as superintendent at the Madill plant. Mr. Ford was assistant superintendent of the Gladewater, Tex., plant at the time it was acquired by Warren through purchase of the Hanlon companies. He later was advanced to the superintendency of the Graham, Okla., plant and remained there until that plant was was shut down recently.

* * *

Bruce H. McCully recently was put in charge of all refining, pipeline and producing operations for Cooperative Refinery Association, Kansas City, Mo. His assistant in charge of refining is **Miles Cowden.**

Dr. Frederick D. Rossini, chief of the thermochemistry and hydrocarbons section of the National Bureau of Standards, has been appointed professor and head of the chemistry department at Carnegie Institute of Technology, effective July 1, 1950.

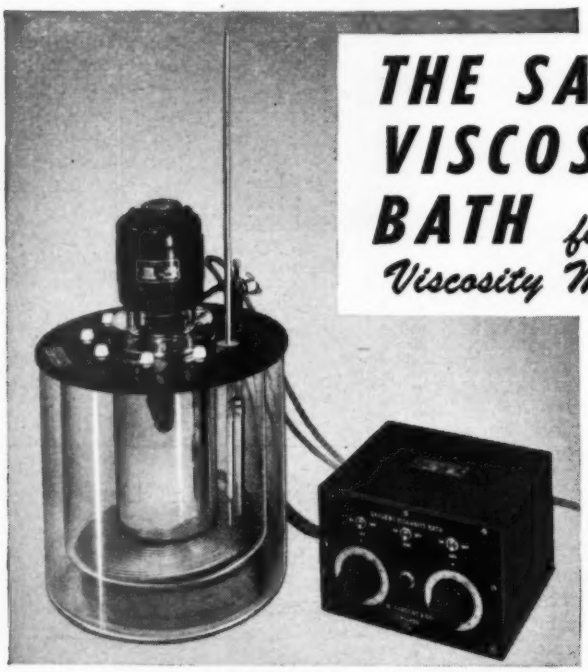
* * *

George C. Montgomery has been named asst. superintendent-admistrative of Shell Oil Co.'s Wilmington-Dominguez, Calif., refinery. He was formerly asst. superintendent-operations. In his new position he will be concerned with personnel, industrial relations, plant protection, safety, public relations, employe activities and employe training.

George A. Lorenz succeeds Mr. Montgomery as asst. superintendent-operations. Mr. Lorenz has been on special assignment in the design of process facilities for Shell during the past 18 months.

* * *

Dr. Herman E. Ries, Jr. of Sinclair Refining Co.'s research laboratories at Harvey, Ill., has been awarded the Ipatieff Prize in Chemistry for 1950. The prize, $3000, is awarded every three years for achievement in the study of catalysts or high pressure, and cites Dr. Ries for his contributions to the knowledge of catalysts, particularly those used in hydrocarbon conversion. The award is administered by American Chemical Society.



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MEETINGS . . . for the Oil Man

DECEMBER

29-30, American Chemical Society, Division of Industrial and Engineering Chemistry, Christmas Symposium on Absorption and Extraction, Columbus, Ohio.
29-30, American Assn. for the Advancement of Science, Chemistry Section, Annual Meeting, Hotel Statler, New York.

JANUARY

3-6, American Meteorological Society, 30th Anniversary and 104th National Meeting. Air Pollution Symposium, St. Louis.
9-13, Society of Automotive Engineers, Annual Meeting and Engineering Display, Book-Cadillac Hotel, Detroit.
16-19, First Plant Maintenance Show, Public Auditorium, Cleveland.
23-27, American Standards Assn., Seminar on Industrial Standardization, Engineering Societies Building, New York.

FEBRUARY

12-16, American Institute of Mining & Metallurgical Engineers, Annual Meeting, Penna. Hotel, New York.
26-Mar. 1, American Institute of Chemical Engineers, Regional Meeting, Rice Hotel, Houston.
27-Mar. 3, American Society for Testing Materials, Committee Week and Spring Meeting. Hotel William Penn, Pittsburgh.

MARCH

26-30, American Chemical Society, 117th National Meeting (divided), Houston.
27-29, Western Petroleum Refiners Assn., 38th Annual Meeting, Plaza Hotel, San Antonio.

APRIL

3-6, National Assn. of Corrosion Engineers, Jefferson Hotel, St. Louis, Mo.
5-7, Illinois Institute of Technology, Midwest Power Conference, Sherman Hotel, Chicago.

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EDITORIAL VIEWPOINTS...

Opinions and Comments on Current Topics

All Is Not Lost If More Gas Does Find Its Way to Markets

A GLOOMY picture of the future for the distillate fuel market in parts of New England and the east, when an additional 2,600,000 Mcfd. of natural gas now authorized enters these consuming areas, was predicted by E. Holley Poe, of New York, in an address before the recent API annual meeting. This quantity of gas, said Mr. Poe, is equal in heating value to 50% of the distillate fuel sold in this area in 1948.

Existing gas distributing companies within access of the new pending and proposed lines are reported to have nearly 7,000,000 customers now using an average of 25 Mcf. of manufactured gas, as against an average of 75 Mcf. for natural gas customers. Mr. Poe believes many of these customers will switch from oil or coal to gas for space heating when supplies of the natural product are available. Several factors come to mind, however, that would limit the extent of such a shift.

Many of the present local gas distributing systems were never intended to handle more than a cooking and water heating load. In fact some were installed originally to handle only street lighting. Even though the effective system capacity on a Btu. basis could be doubled with natural gas, it is doubtful if the capacity would be then sufficient to take over space heating and industrial demands. Urban householders heating with oil have considerable investment in equipment giving about as convenient service as gas can supply. Even with an unfavorable economic factor, a more logical switch would seem to be from coal to gas, particularly if John Lewis continues to intimidate the public and the coal industry.

Looking some years ahead, when the changes Mr. Poe predicts would make themselves felt, if the present avenues of consumption of distillate products keep widening, and if fuels for jet planes are to come from the refiners' distillate cuts, the oil companies might even welcome a slackening in the growth of the heating oil markets.

"Specs" for Railroad Diesel Fuel

PERENNIALLY, the matter of standard specifications for railroad diesel fuel comes up. The latest suggestion is from an engineer of tests for the Baltimore & Ohio, as presented before the SAE National Diesel Engine Meeting in St. Louis early in November. This authority poses the question, "Does it not appear that the time has come, in view of the wide acceptance of diesels by railroads, for the railroads, the engine builders and the oil companies to get together for the purpose of writing and maintaining a mutually acceptable railroad fuel oil specification?"

In the present state of flux in demand not only for diesel fuel oil but also for another distillate fuel, heating oils, arbitrary standards for railroad diesel fuel would likely have just the opposite to the desired effects, namely, to increase the available supply and if possible to reduce the cost. The burden on the refiner in manufacturing supplies adequate for present and anticipated utilization would be greatly increased.

The rate of consumption of diesel fuel by the railroads has been greater than for any other petroleum products and at present the volume used is approaching 100,000 b/d. Competent authorities have estimated that, by 1953, the railroads will be using 200,000 b/d. This growing rate of utilization does not take into account the increases in consumption of diesel fuels by automotive vehicles, and in marine and other services.

Developments entirely outside the fuels themselves also in the not far distant future may influence the characteristics of diesel fuels required for railroad use. The new types of special heavy-duty motor oils which have been developed since the war may make it possible to use satisfactorily fuels of higher sulfur content than are now considered practical. This possibility is now being explored by some oil companies and at least one engine builder. Improvements in engine design now being studied also may temper the fuel requirements.

The petroleum refiners in the main have adequately met the greatly increased demands for diesel fuels from all types of users in the postwar period. Competition among them for this business is the best insurance that suitable fuels will continue to be supplied in the volumes demanded, without standard specifications.

The Wildcatting Paid Off

UNDER the intriguing title, "API Wildcatting in Some Interesting Areas", Chairman R. E. Wilson of the API directors central Research Committee, presented the recent annual API meeting with a most enlightening account of the basic petroleum research program supported by the industry under API direction. Literally thousands of reports have been issued over the years on the various individual projects, and hundreds of scientists, both in and outside the industry, have participated in the work, which started in 1926. On too few occasions, however, have those directing the program seen to it that an overall non-technical report was presented to the industry at large, such as that given by Dr. Wilson.

While entirely fundamental in character, the results of the API basic research program have already many times paid out their cost, through supplying data which has formed the basis for improved operating techniques and equipment used by oil companies. For example, a project which began as a study of the behavior of gas in the ground as an instrument of oil production developed important information about the solubility of oil in gas and the accompanying phenomenon of retrograde condensation. Through its practical application millions of barrels of distillate produced with gas under high pressure conditions in the ground were saved which otherwise would have been lost.

The wartime manufacture of aviation gasoline was greatly expedited by the knowledge of the properties of individual hydrocarbons in the gasoline range which had been developed in API research projects. New methods of analysis of hydrocarbons have been discovered.

Wider acquaintanceship throughout the industry with the API research program would add still more to the benefits the oil companies can derive from the storehouse of valuable data now being accumulated.

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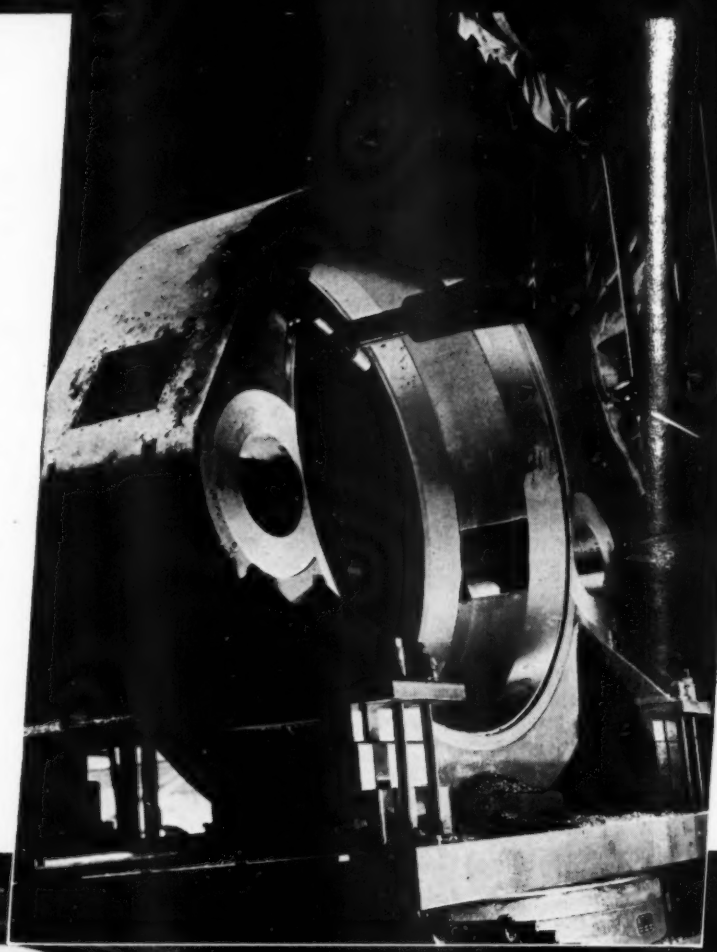
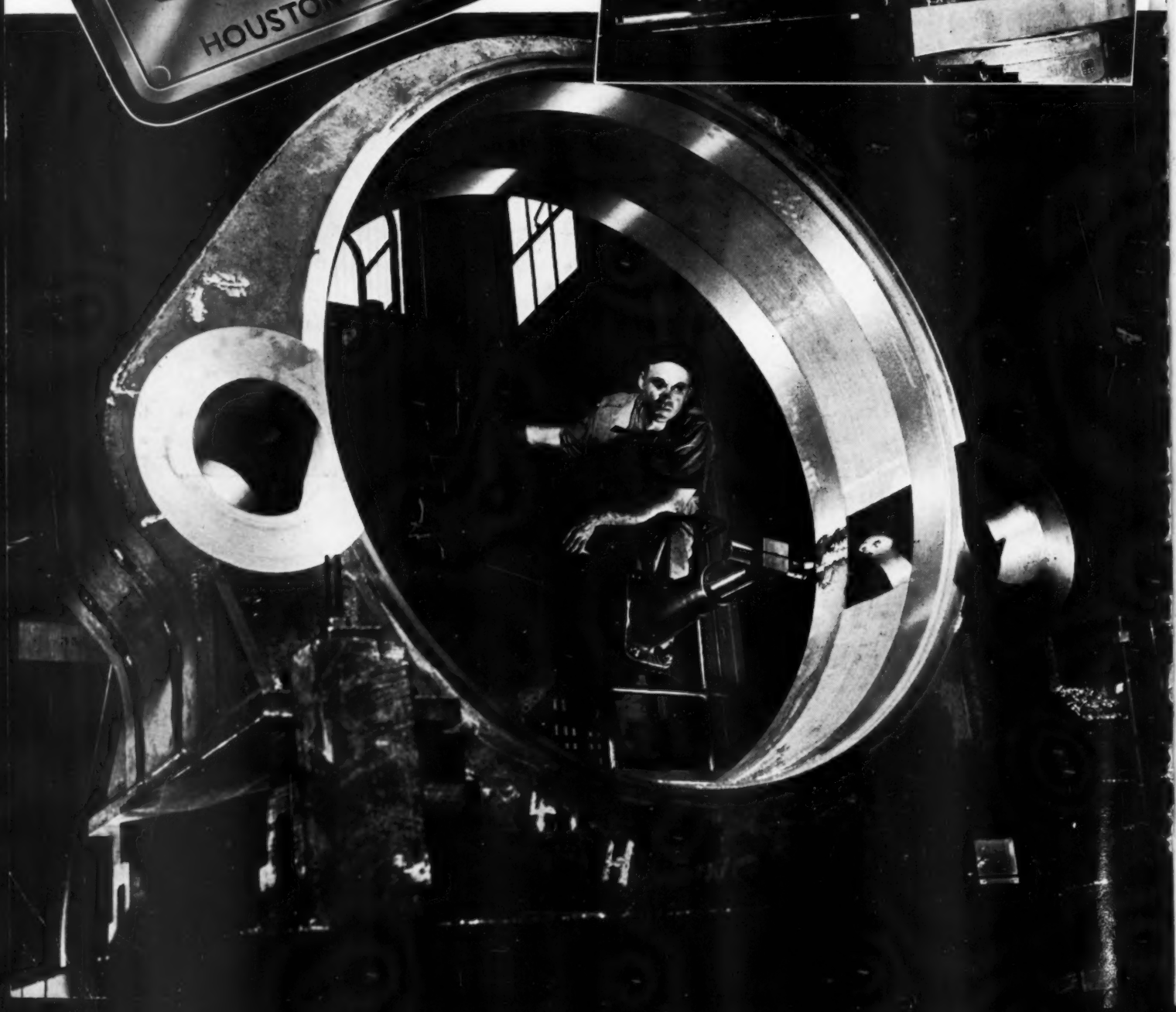
Fabricated and completely machined by WYATT'S to your specifications. The example pictured is a pump housing with shrunk brass bearings.





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BR -- Book Reviews
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EP -- Equipment Patent Review
Q&A -- Gasoline and Cycling Plant Operation
LP -- Laboratory Practices
PP -- Plant Practices
PT -- Patent Trends
T -- Tomorrow in Petroleum Technology
WN -- What's New

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